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# Abstract

In this study, high-performing developmental dyslexics' (HPDDs) use of context to aid word recognition was examined. The experimental group (RD) consisted of 25 current university students or recent graduates whose performance on the elementary education section of the modified Adult Reading History Questionnaire indicated significant reading acquisition difficulties. The control group (ND) consisted of 31 participants who had no history of reading problems and were current university students. All participants were given a battery of standardized reading and cognitive processing tests to establish their current performance level. Three experiments were conducted. Experiment 1 examined how semantic and syntactic manipulations of sentence context primes affected the lexical access process. Experiment 2 examined if RD and ND groups differed in use of meaning frequency and context strength to facilitate lexical ambiguity resolution. Finally, Experiment 3 examined the effect of text saliency and contextual-only rather than contextual-semantic relationships between the primes and target words. The results of Experiment 1 indicated no differences in how the congruent context or syntactic manipulations affected the performance of the two groups; however, only the RD group displayed a significant inhibition effect in the incongruent condition. Experiment 2 found robust between group differences for context strength and meaning frequency as well as a significant group by meaning frequency by context strength interaction. Finally, Experiment 3 indicated that the high salient story inhibited the RD group's performance but facilitated the ND group's performance, and that contextual priming had a significant effect only on the ND group' performance. On the whole, the results of the current study suggest that (a) HPDDs' word processing is context sensitive,

(b) slower reading rates and weaker decoding skills are not solely responsible for the differences in the context use, and (c) context effects may result from HPDDs' ability to comprehend the context as a whole and not just the relationships between individual words. These results imply that interactive language processing is a characteristic of HPDDs rather than a result of slow decoding or text reading speed.

# Acknowledgement

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# Dedication

I dedicate this thesis to my parents. Mom and Dad, you have always supported and encouraged me to exceed the limits imposed upon me by both myself and others. If it were not for you, I would not be who I am today. For all of the accomplishments in my life, I thank you.

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# HIGH-PERFORMING DEVELOPMENTAL DYSLEXIC'S USE OF COGNITIVE COMPENSATORY STRATEGIES

## CHAPTER 1

## INTRODUCTION

"The whole notion of modern-day education is founded on two assumptions about language. The first assumption concerns language skills as desired outcomes of education – language as a goal. The second concerns language skills as instruments in the process of education – language as a learning tool" (Limage, 1990, p. 227). Since language is necessary for an individual to function as an active member of society, society must ensure that its individuals are able to use language effectively. Effective language skills must become a major goal of education; while at the same time, language should be considered as a learning tool that advances an individual from vocal to written communication. As the education system relies so heavily on written material to transmit information, it is usually through the school system that the individual gradually becomes proficient in the use of written communication.

Although the majority of individuals acquire adequate oral communication skills or compensatory oral language skills (e.g., American Sign Language), many individuals encounter difficulties with written material. Approximately 80% of diagnosed learning disabilities are reading related (Bell, McCallum & Cox, 2003) and 5 to 10% (some estimates are a high as 20%) of the school-aged population are diagnosed with specific reading difficulties (i.e., dyslexia) (Brosnan, Demetre, Hamill, Robson, Shepherd, & Cody, 2002). Therefore, meeting the learning needs of individuals with reading difficulties and developing strategies to help alleviate these difficulties should be a major goal of education.

To meet this goal, educators have developed a variety of instructional and remedial techniques to help children to communicate successfully through the written word. Instructional techniques such as phonics, whole language, literacy based and language experience have each been argued to offer the greatest success in promoting reading. In reality, several techniques are necessary as no single strategy or a single combination of strategies can meet the instructional needs of all individuals. Although the majority of children develop adequate reading skills through instructional techniques, some individuals continue to struggle with reading all their lives. Such individuals are identified as having developmental dyslexia when it is demonstrated that they are unable to master basic reading processes, such as sound blending, despite adequate intelligence and educational opportunities and the absence of neurological impairment.

In the past, developmental dyslexia has often been attributed to laziness or lack of intelligence. Today, not only does research suggest significant neurological differences between normal readers and individuals with developmental dyslexia (Ingvar et al., 2002; Robichon, Bouchard, Démonet, & Habib, 2000; Rumsey et al. 1992; Salmelin, Service, Kiesilä, Uutela, & Salonen, 1996), but it has also revealed cognitive differences in the reading processes of normal readers and individuals with developmental dyslexia (Bruck, 1992; Bruck, 1993b; Gottardo, Siegel, & Stanovich, 1997; Lefly & Pennington, 1991). As a result, it is now widely accepted that individuals with developmental dyslexia do not experience reading difficulties because of intellectual or motivational deficits, but because of difficulties in phonological processing that may be neurologically based.

The phonological processing difficulties encountered by individuals with developmental dyslexia generally result in poor word recognition abilities, which in turn leads to slower reading rates because of the time needed to decode words (Gallagher, Laxon, Armstrong & Frith, 1996; Lefly & Pennington, 1991). Concentrating on decoding words may negatively influence reading comprehension because the limited resources of short-term memory are being used for decoding and not comprehension (van der Leij & van Daal, 1999). Some individuals with developmental dyslexia, however, show unexpectedly high levels of reading comprehension when compared to their word recognition abilities (Bruck, 1990; Ransby & Swanson, 2003). Their high levels of reading comprehension may be a result of their use of contextual cues to compensate for their inadequate decontextualized word recognition skills (Bruck, 1990; Nation & Snowling, 1998).

In general, the cognitive characteristics of individuals with developmental dyslexia imply that developing normal reading abilities might be unattainable. In fact, current reading acquisition models and reading processing models typically accept this position. However, many individuals with developmental dyslexia are able to obtain academic success and are referred to as high performing developmental dyslexics (HPDDs). Some of these HPDDs have managed to cognitively compensate for their reading difficulties enabling them to read at par with normal readers. Others have developed socio-cognitive compensatory strategies that enable them to obtain academic success despite their persistent reading difficulties.

This study examines how HPDDs use context to aid word recognition. Although it is generally accepted that context is used to some degree by all readers, it is unclear whether HPDDs use context differently than normal readers and whether there is a difference in the effect context has on their word recognition. To clarify how HPDDs use context in the word recognition process, the following questions will be examined: (a) how a sentence context prime affects the lexical access process, (b) how sensitive the initial meaning activation of a homograph is to the prior context, (c) how the presentation of two words (a prime and a target) in the same story creates a contextual connection between them when they are otherwise not semantically related, and (d) the effect of overall contextual salience. By understanding how HPDDs use context as a cognitive compensation strategy, instructional methods and techniques can be developed to help individuals with developmental dyslexia achieve academic success.

## Definitions of Terms

For the purpose of the current research, the following terminology will be used.

*Compensation*: The use of a strategy or behaviour that enables an individual with developmental dyslexia to read and/or comprehend text at average or above average levels despite deficiencies in phonological sensitivity.

*Context* : The parts of a discourse that surround a word or passage and can throw light on its meaning (Merriam-Webster Online: http://www.m-w.com/cgi-bin/dictionary)

*Context effects*: The effects on a cognitive process, such as word identification, of the information surrounding the target stimuli.

*Dyslexia*: A specific learning disability that is neurobiological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge (Lyon, Shaywitz, & Shaywitz, 2003, p. 2).

*Facilitation (also see inhibition)*: The faster recognition of a word; or the faster meaning resolution of an ambiguous word.

*Grapheme-phoneme-correspondence*: The relationship between the spelling of a word and its corresponding sounds.

*High Performing Developmental Dyslexics*: Individuals with developmental dyslexia who, despite a significant history of reading difficulties, experience academic success at the post-secondary level.

*Homograph*: one of two or more words spelled alike but different in meaning or derivation or pronunciation (Merriam-Webster Online: http://www.m-w.com/cgi-bin/dictionary).

*Homograph meaning frequency*: The relative frequency that participants provide semantic associations to each of the possible meanings of a homograph. For example, the frequency with which the word *bark* generates the word *dog*.

*Inhibition*: The slower recognition of a word; or the slower meaning resolution of an ambiguous word.

*Integration processing*: A post-access process whereby lexical representations are combined with relevant internal information, such as schemas (Twilley & Dixon 2000).

*Lexical access*: The sufficient overlap between a word and its internal representation resulting in the recognition of the word (Balota & Chumbly, 1985[j1]).

*Lexical-lexical priming*: The associative relationship between words in the lexicon, whereby the presentation of a word immediately prior to the presentation of a second word results in facilitating the recognition of the second word.

*Lexical processing*: The process of recognizing individual words by directly accessing the mental representation of a word from the lexicon.

*Lexicon*: A mental store believed to contain an individual's knowledge of words (e.g., spelling, pronunciation, definitions, part of speech, etc.) (Galotti, 1999).

*Phonological processing*: The broad process of using the sound structure of a spoken language in processing written and oral information (Wagner & Torgesen, 1987).

*Phonological sensitivity*: The awareness of the sound structure of a spoken language and the ability to segment speech into sublexical units such as syllables, onsets and rimes, or phonemes (Bruck, 1993b). Phonological sensitivity is also referred to as phonological awareness. Phonological awareness is not used in this dissertation because the term *awareness* implies a conscious effort on the part of the individual to establish a relationship between a letter and its sound. Although under some circumstances an individual will make a conscious effort to be aware of this relationship, this is not always the case and thus phonological sensitivity is preferred here as the more appropriate term.

*Priming*: The facilitation in responding to one stimulus as a function of prior exposure to another stimulus (Galotti, 1999).

*Schema*: The organized framework for representing knowledge that typically includes characters, plots, and settings, and incorporates both general knowledge about the world and information about particular events (Galotti, 1999).

*Semantic network*: A depiction of semantic memory consisting of nodes (which roughly correspond to words or concepts) and connections between them (Galotti, 1999).

*Semantic priming*: The semantic relationship between words in the lexicon, whereby the presentation of a word or context immediately prior to the presentation of a semantically related word results in facilitating its recognition.

*Spreading activation*: The assumption that each word stored in the lexicon is interconnected with other words in the lexicon. When a target word is presented it becomes activated and serves as a source of activation for all of the words associated with the target word. In addition, as each new word becomes activated, it in turn also serves as a source of activation for all of the words associated with it. This spreading process continues onward throughout the lexicon.

*Sublexical processing*: The reliance on grapheme-phoneme-correspondence to decode words (Aaron, Wilczynski & Keetay, 1998; Bjaalid, Høien, & Lundberg, 1997; Brown, 1997).

*Target salience*: The strength of the semantic relationship between the target word that is named and the biased meaning of the homograph that precedes it.

# CHAPTER 2

# LITERATURE REVIEW

## The Characteristics of Developmental Dyslexia

During the kindergarten years, many teachers help to develop children's phonological sensitivity through the use of rhyming and alliteration activities. In grade one, children further develop phonological sensitivity through phoneme and syllable counting tasks as well as reading and listening to nursery rhymes and poetry. As they progress through elementary school, children begin to apply phonological sensitivity in their attempts to spell and decode both familiar and unfamiliar words. All these tasks are used, in conjunction with others, to meet curriculum guidelines that specify that children must be able to use syntactic, semantic, graphophonic, and pragmatic cues to construct and confirm contextualized and decontextualized word meaning (Western Canadian Protocol for Collaboration in Basic Education, 1998; Ministry of Education and Training, 1997, 1998). Although schools attempt to give their students a strong foundation in reading literacy, some children experience difficulties acquiring the skills needed to become successful readers despite their normal intelligence and socioeducational opportunities. These children are often identified with exceptionality of developmental dyslexia. The characteristics of developmental dyslexia, however, are more than a simple discrepancy between intelligence and reading ability.

This literature review will begin by examining the neurological, cognitive, behavioural and socio-cognitive characteristics of individuals with developmental dyslexia. Next the review will focus on the concept of compensation in reading acquisition and reading process models followed by a description of interactive and modular theories of reading. Finally the purpose of the current research is explained together with the research questions.

## *Neurological Characteristics*

On one level, developmental dyslexia can be examined as a neurological phenomenon. When individuals with developmental dyslexia are compared to individuals with normal reading abilities, differences have been found in the activation levels in the region of the plana temporale, left posterior inferior temporal lobe, and the temporoparietal lobe in the left hemisphere (Robichon et al., 2000; Rumsey et al., 1992; Salmelin et al., 1996). These differences are important as the temporal lobe is believed to be responsible for receiving auditory information and for controlling memory and language (Hagman et al., 1992). Within the temporal lobe, Wernicke's area has been found to be less active in individuals with developmental dyslexia, while Broca's area is more active (Paulesu et al., 1996; Robichon et al., 2000; Salmelin et al., 1996). Furthermore, less activation has been found in the angular/supramarginal gyri, an area believed to be critical to the reading process (Brunswick et al., 1999; Ingvar et at., 2002; Paulesu et al., 1996; Robichon et al., 2000; Rumsey et al., 1992) because it is used in lexical processing (Ingvar et al., 2002). Less activation in the angular/supramarginal gyri suggests a deficit in lexical processing and may suggest that the primary effects of dyslexia are found in the parietal and temporal regions (Ingvar et al., 2002). Overall, it is speculated that Broca's area is important when converting letters into whole words, but when words are segmented at the letter level, the angular gyrus is used. Thus, when reading non-words, the increased activation in the Broca's area suggests that individuals with developmental dyslexia are using a whole-word strategy and implies impairment in the temporal area (Ingvar et al., 2002, p. 264).

A recent study conducted by Eden et al. (2004), examining the neural changes in adults with developmental dyslexia who received training in phonological processing, found that prior to training the participants with developmental dyslexia displayed the neurological characteristics described above. After undergoing training in phonological processing, the participants with developmental dyslexia displayed increased activity in bilateral parietal cortex and right hemisphere perisylvian structures. Eden et al. concluded that adults with developmental dyslexia can benefit from training in phonological processing that can result not only in an increase in text and nonword reading accuracy, but also in the activation of the right parietal and perisylvian structures. They speculated that the neural changes experienced by the participants with developmental dyslexia suggest a specific neural location for compensatory mechanisms.

Shaywitz et al. (2003) also examined the neural system employed by individuals with developmental dyslexia. They compared the neural systems of compensated readers[1], persistently poor readers (non-compensated) and individuals without reading difficulties. They found that the compensated readers appeared to rely on compensatory neural systems. Specifically, in a pseudoword rhyming task both the compensated readers and persistently poor readers displayed an "underactivation in posterior neural systems located in the superior temporal and the occipitotemporal regions" (p. 28). In addition, the compensated readers also displayed activation in the right superior frontal, the right middle temporal gyri, and the left anterior cingulate gyrus. When reading real words, the compensated readers demonstrated under activation in left posterior regions while the persistently poor readers activated posterior systems. In addition, when the persistently poor readers were compared to individuals who did not have reading difficulties there were no differences in the temporoparietal area, but there was increased activation in the occipitotemporal region, (p. 28). While their study appears to suggest that there are neural differences between compensated and non-compensated developmental dyslexics, it should be noted that the two groups were not comparable on intelligence. Specifically, the compensated developmental dyslexics had a full-scale intelligence quotient in the average range, while the non-compensated developmental dyslexics were below average. Therefore, the neural differences displayed in Shaywitz et al.'s study may be attributed to other factors beyond the reading ability of the participants.

---

[1] Compensated readers were defined as individuals who no longer experienced the reading difficulties they had in childhood.

## *Cognitive and Behavioural Characteristics*

### *Cognitive*

As previously stated, one of the defining cognitive characteristics of individuals with developmental dyslexia is that despite average or above average intelligence, as measured by a standardized intelligence test, they continue to experience reading difficulties. For example, although high-performing developmental dyslexics perform at par with normal readers on general cognitive ability tasks, they do not necessarily perform at par on reading and/or spelling tasks (Hatcher, Snowling, & Griffiths, 2002; Rack, 1997; Ransby & Swanson, 2003). The basic assumption of the discrepancy model of specific reading difficulties is that an individual with developmental dyslexia has a cognitive disability that is restricted to reading tasks and does not extend into other cognitive domains (Stanovich, 1991). In other words, developmental dyslexia can be viewed as a domain-specific processing disorder rather than a central cognitive mechanism disorder with widely distributed effects (Stanovich, 1991). Thus, the discrepancy model holds that a developmental dyslexic is an individual who is experiencing reading difficulties that cannot be explained by their general level of cognitive functioning.

There are several problems with the discrepancy model. First, it may be inappropriate to apply this model to HPDDs. Specifically, it is possible that HPDDs have compensated for their reading difficulties to such a degree that a discrepancy between intelligence and reading ability no longer exists (e.g., Rack, 1997). Second, there are few standardized tests for reading and spelling for individuals over 17 years of age (Beaton, McDougall & Singleton, 1997). The lack of age appropriate standardized reading and spelling tests makes it difficult to identify the presence of a discrepancy since it is possible that adults will reach a ceiling point of a reading or spelling test because it was designed for individuals who are younger than 18 years of age. Third, there are poor readers who may or may not have a discrepancy between intelligence and reading ability and yet still display equivalent deficits in decoding (Kelly, 1998; Siegel, 1992). The inconsistent occurrence of a discrepancy between intelligence and reading ability suggests that not only is it inappropriate to use the presence of a discrepancy as a criterion for identification for the presence of dyslexia, but it is also irrelevant. Instead, it may be more appropriate and relevant to look for a discrepancy in reading abilities (e.g., phonological processing, decoding) between an individual with reading difficulties and a normal reader of the same age and level of education (Beaton et al., 1997).

A final problem with the discrepancy model is that general intelligence as measured by the WAIS-R is not necessarily associated with reading rate and reading comprehension (Aaron, 1985). However, while nonverbal IQ is not a good predictor of word reading performance, vocabulary knowledge as measured by the WAIS-R vocabulary score is a unique statistical predictor of the ability to read familiar words (Gottardo et al., 1997), Therefore, "a measure of explicit knowledge of vocabulary such as the WAIS-R vocabulary score should be included in an assessment battery" (p. 52). Furthermore, Gottardo et al. maintain that the use of a standardized oral vocabulary score may assist in predicting those individuals who are able to use stronger vocabulary skills to partially compensate for their weaker decoding skills. The problem with Gottardo et al.'s supposition is the fact that HPDDs may have both strong vocabulary knowledge and a strong ability to read familiar words (Elbro, Nielsen & Petersen, 1994; Beaton et al., 1997; Rack, 1997; Unsworth & Pexman, 2003). It may be more appropriate to examine a discrepancy between intelligence and phonological processing abilities (e.g., non-word reading), as weaknesses in the domain of phonological processing remain throughout dyslexics' lives regardless of their ability to compensate for their reading difficulties.

### *Phonological Sensitivity*

It is essential, at this point, to establish a clear distinction between phonological processing and phonological sensitivity. Wagner and Torgesen (1987) refer to phonological processing as the broad process of using the sound structure of a spoken language to process written and oral information. Within this process, speech is perceived as distinct sounds or phonemes. Each phoneme is comprised of a group of phones, which can be considered variations of the same sound. Phonological sensitivity (also referred to as phonological awareness) refers to the awareness of the sound structure of a spoken language and the ability to segment speech into sublexical units such as syllables, onsets and rimes, or phonemes (Bruck, 1993b).

Phonological sensitivity is typically the main weakness for individuals with developmental dyslexia (Gallagher et al., 1996; Meyler & Breznitz, 2003; Ransby & Swanson, 2003). It has been found that regardless of age or reading level individuals with developmental dyslexia do not develop appropriate phonological sensitivity abilities (Bruck, 1992; Bruck, 1993b; Gallagher et al., 1996; Meyler & Breznitz, 2003; Ransby & Swanson, 2003; Wilson & Lesaux, 2001). As such, phonological sensitivity may be used as a predictor of reading ability, regardless of the age of the individual, because of the positive relationship between phonological sensitivity and reading ability (Gottardo et al., 1997). The relationship between phonological sensitivity and reading ability can be interpreted in three different ways.

First, phonological sensitivity may be viewed as a prerequisite for learning to read (Bruck, 1993b). The idea of phonological sensitivity as a prerequisite is based on the premise that the stronger a person's ability to recognize individual speech sounds as they relate to the spelling of a word, the better their reading acquisition skills. Phonological sensitivity, however, is not just one simple skill. Phonological sensitivity can be considered a complex skill which is developed from a subset of skills consisting of, but not necessarily limited to, sensitivity to rhyme, auditory discrimination, syllabic segmentation, phonemic manipulation, and phonological coding in short-term memory (de Gelder & Vroomen, 1991). It may be argued that certain phonological sensitivity subskills, specifically phonemic sensitivity, emerge as a result of the development of spelling-sound correspondences. Thus, an alternative manner of interpreting the relationship between phonological sensitivity and reading ability is that phonological sensitivity, or at least the more advanced levels of it such as phonemic sensitivity, may be viewed as a product of learning to read (Bruck, 1993b). Finally, Bruck (1993b) argues that the relationship between phonological sensitivity and reading acquisition may be viewed as bidirectional and interactional. That is, an individual must have some level of phonological sensitivity (e.g., onset-rime) in order to begin to read, but as the individual develops his/her reading skill, his/her understanding of the relationship between a word's spelling and its corresponding sounds also develops. As a result, through the individual's increasing understanding of spelling-sound relations, an awareness of phonemes develops.

In general, it has been found that individuals with developmental dyslexia have poor knowledge of spelling-sound correspondences (Vellutino, Fletcher, Snowling & Scanlon, 2004). As the normal reader's reading ability and age increases, his/her knowledge of spelling-sound correspondences also increases while at the same time there is a decrease in the usage of that knowledge in word recognition because the reader is able to recognize more words based on direct visual orthographic[2] information (Bruck, 1993b). As a normal reader develops his/her reading skills, the application of spelling-sound correspondence is used mainly for the recognition of unfamiliar words (Bruck, 1993b). Bruck (1993b) suggested further that since individuals with developmental dyslexia have poor spelling-sound knowledge, this affects their ability to develop accurate orthographic representations of words, which then affects their ability to recognize a word on a direct visual basis. As a result, individuals with developmental dyslexia continue to use spelling-sound correspondences to recognize both high- and low-frequency words (Bruck, 1993b).

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[2] Orthographic knowledge refers to the knowledge a reader has about spelling patterns. Orthographic knowledge is necessary for accurate word recognition in English because groups of letters frequently map onto a single sound. For example, in the word *boat*, the *oa* must be recognized as a unit that maps onto the long *o*. In addition, orthographic knowledge enables readers to discriminate between common homophones, such as *to* versus *two* or *there* versus *their* (Spear-Swerling & Sternberg, 1996).

In addition, Bruck (1992) found that although individuals with developmental dyslexia experience little development in phonemic sensitivity, their awareness of onsets and rimes develops with their reading skill. This finding is opposite to the pattern found in normal readers whose phonemic sensitivity increases with reading skill while onset and rime awareness does not. Bruck's (1992, 1993b) results suggest that despite increases in reading skill individuals with developmental dyslexia develop little phonemic sensitivity. Therefore, in terms of the three possible ways in which phonological sensitivity influences reading acquisition it appears that normal readers have a bidirectional relationship between word recognition and phonemic sensitivity (Bruck, 1992). Individuals with developmental dyslexia, however, do not display this relationship.

> That is, for normal children, it is clear that awareness of onset-rime units are acquired very early; however, phoneme awareness develops as a function of word recognition skills. Furthermore, the development of phoneme awareness is associated with increases in the use of orthographic information when making phonological judgements. For the dyslexics, it appears that word recognition skill facilitates awareness of onset-rime units, but it has much less if any impact on the development of phoneme awareness and on the use of orthographic information (Bruck, 1992, p. 885).

Since phonological sensitivity can be considered a main deficit in individuals with developmental dyslexia, it is important to understand the impact phonological sensitivity has on word reading and reading comprehension. Such an understanding may help clarify why many adults with developmental dyslexia report that they have overcome their reading disability, while still experiencing difficulties when reading new words (Elbro et al., 1994).

### *Reading Comprehension and Word Reading*

Elbro et al. (1994) examined the reading comprehension levels of adults with developmental dyslexia in terms of phonological sensitivity and semantic word knowledge. They found that regardless of the education or the amount of daily reading, the reading comprehension of adults with developmental dyslexia was affected by phonological sensitivity and not by their understanding of what the words mean (semantic word knowledge). However, Ransby and Swanson's (2003) study, which also examined the reading comprehension skills of adults with a childhood diagnosis of dyslexia, found that although phonological sensitivity does influence reading comprehension, this influence is no greater than the influence of higher order processes (i.e., listening comprehension, vocabulary, working memory, and general knowledge). Furthermore, Ransby and Swanson found that phonological sensitivity did not play a dominant role in mediating the impact higher processes have on reading comprehension. Therefore, they concluded that there is no support for the belief that phonological sensitivity is the primary mediator of reading comprehension in adults who have a childhood diagnosis of dyslexia. Although the impact phonological sensitivity has on reading comprehension may be debated, the implications it has for word recognition are clearer.

One manner in which phonological sensitivity influences the reading abilities of individuals with developmental dyslexia is in the speed at which they can identify words. Although some adults with developmental dyslexia have compensated for their reading difficulties in terms of accuracy, they continue to read at a slower rate than normal readers (Bruck, 1990; Lefly & Pennington, 1991; van der Leij & van Daal, 1999). A slower reading rate may be the result of weak phonological sensitivity (Lefly & Pennington, 1991; Gallagher et al., 1996). Specifically, having weak phonological sensitivity requires an individual to spend more time decoding words, thereby decreasing the speed at which they can read. Thus, although some individuals with developmental dyslexia may be able to compensate for their reading accuracy and reading comprehension, this compensation requires the use of additional time thereby decreasing the speed at which they read.

In terms of normal reading ability, the automatization of word-recognition skills is often considered essential for reading comprehension due to the limitations of human attentional capacities (van der Leij & van Daal, 1999). As a result, if we focus on decoding individual words, we will be unable to comprehend what we are reading because we do not have the attentional capacity to process both meaning and word construction (Ransby & Swanson, 2003; van der Leij & van Daal, 1999). In addition, when Ransby and Swanson (2003) matched adults with a childhood diagnosis of dyslexia with normal readers based on word recognition and intelligence they found that the adults with a childhood diagnosis of dyslexia scored lower than normal readers on cognitive measures related to working memory and lexical processing. They concluded, therefore, that poor readers have a small general working memory capacity that is independent of reading (p. 552). In terms of developmental dyslexia, therefore, poor decoding skills may affect comprehension abilities because the effort required to decode words detracts from the attention needed for comprehension as well as consuming their limited working memory capacity.

Bruck (1990) examined the word recognition abilities of college students with childhood diagnosis of dyslexia. She found that not only do adults with developmental dyslexia continue to encounter word recognition difficulties, particularly in terms of slower response speed, but they also relied on the "use of spelling-sound information, syllable information, and context to assist word recognition" (p. 450). Similarly, Aaron (1985) reported that the reading rate of high performing developmental dyslexics is influenced by the ability to perform grapheme-phoneme (spelling-to-sound) conversions. It is unclear, however, whether continued use of word-recognition processes that are normally associated with poor reading results in a decreased ability to automatically recognize a word or whether the opposite is true and the inability to develop automatized word recognition skills results from the continued use of processes normally associated with poor reading.

Decoding difficulties may also manifest in the ability to read unfamiliar words (non-words/pseudowords). If an individual with developmental dyslexia encounters a word that he/she does not recognize (e.g., ginglymus), no lexical representation is available. When this occurs, a sublexical process must be used to decode the word using grapheme-phoneme rules (Aaron et al., 1998; Bjaalid et al., 1997; Brown, 1997). In general, it has been found that individuals with developmental dyslexia experience a deficit in unfamiliar word (non-word) reading (Aaron, 1987; Aaron, Olsen & Baker, 1985; Ben-Dror, Pollatsek & Scarpati, 1991; Brown, 1997) and this may be attributable to poor spelling-to-sound correspondence skills (Pennington, Lefly, van Orden, Bookman, & Smith, 1987; Vellutino et al., 2004).

### *Spelling*

Despite the fact that some HPDDs are able to read at or above normal levels, the majority of these individuals continue to experience spelling difficulties. These spelling difficulties persist regardless of the age or reading ability of the individual (Curtin, Manis, & Seidenberg, 2001; Bruck, 1993a). A possible explanation for why spelling difficulties persist even though a developmental dyslexic has compensated for his/her reading difficulties is that spelling places a greater demand on many of the skills used in both reading and spelling (e.g., phonemic sensitivity) (Curtin et al., 2001). For example, there may be more ways to present a sound than to pronounce a particular phoneme. Furthermore, spelling unfamiliar words requires not only an analysis of every phoneme in the word, but also the mapping of phonemes onto the correct corresponding grapheme representation (Curtin et al., 2001).

According to Curtin et al. (2001) spelling may also make greater demands on orthographic processing than reading does. They argue that when reading the individual is provided with a visual representation of the word and the word is embedded within a context. As a result, not only can the reader use the context as a means of predicting the word, but the reader can also sound out the word. For example, when decoding the word *castle* the individual may be able to successfully sound out the first three letters. When the individual encounters the silent *t*, the fact that he/she sees the word *castle* may trigger the recall of the knowledge that the letter *t* is silent. In addition, the individual may use the context to predict the word. When an individual must spell the word *castle*, however, he/she must rely on his/her memory of the letter sequence of the word (orthographic knowledge). Therefore, reading may be viewed as requiring the use of only partial cues while spelling requires detailed and complete information (Snowling, 1987).

Like Curtin et al. (2001), Gallagher and colleagues (1996) maintain that both spelling and reading problems are caused by "difficulties in establishing mappings between orthographic input and phonological output" (p. 500). Specifically, a phonological weakness may suppress the development of segmental phonology which is needed for the development of orthographic representations and decoding skills (Gallagher et al., 1996). In terms of adults with developmental dyslexia, Bruck (1993a) found that their poor spelling-sound correspondences contributed to the poor spelling abilities. Specifically, the dyslexic college students in Bruck's (1993a) study had difficulty with all spelling tasks that involved spelling-sound correspondences. In addition, the dyslexic group used phonological information to spell words, thereby suggesting that dyslexics may not rely on visual information alone when spelling. Although the individuals with developmental dyslexia used phonological information to spell words, the spelling errors made by the dyslexic group suggest that they lacked proper phonological knowledge. This finding corresponds to the research discussed earlier indicating that developmental dyslexia is characterized by poor phonological sensitivity.

While adults with developmental dyslexia, regardless of reading ability, have difficulties using sound-spelling correspondences, some individuals with developmental dyslexia may be able to use morphological knowledge when spelling. Bruck (1993a) argued that the ability to use morphological knowledge when spelling may be related to the amount of exposure the individual with developmental dyslexia has had to print. For example, being exposed frequently to the suffix *-ed* provides an individual with the knowledge that the past tense of *push* is *pushed* and not *pusht* (Bruck, 1993a). It should be noted, however, that currently no studies have examined Bruck's suggestion. Consequently, no firm conclusions pertaining to how morphological knowledge influences the spelling abilities of individuals with developmental dyslexia can be formulated.

### *Emotional, Motivational and Environmental Characteristics*

It is not sufficient just to understand the neurological, cognitive and behavioural characteristics of individuals with developmental dyslexia, an understanding of the emotional, motivational and environmental influences are also necessary. Knowledge of these influences is necessary as they may determine whether or not an individual with developmental dyslexia successfully compensates for his/her reading difficulties.

Scott, Scherman, and Philips (1992) suggested that many individuals with developmental dyslexia experience emotional instability because they do not develop an understanding of their academic difficulties. This emotional instability manifests itself in low self-efficacy. That is, individuals with developmental dyslexia may believe that they are not as capable as their peers and believe that they have failed themselves and others. Furthermore, individuals with developmental dyslexia have cited negative emotions such as fear, shame, anger, frustration, sadness and confusion which can lead to personal alienation and dysfunctional behaviour (Robertson & Czerwonka, 2001). In extreme cases, nervous breakdowns, suicide attempts, delinquency, aggression, and psychosomatic illness have been triggered by the struggles that individuals with developmental dyslexia face (Robertson & Czerwonka, 2001). It is possible that early identification and remediation of reading difficulties would increase the likelihood that individuals with developmental dyslexia would successfully overcome the risk for emotional instability (Scott, Scherman, & Philips, 1992).

The attitude an individual with developmental dyslexia has toward reading is an important motivational factor. Fink (1996, 1998) found that many high-performing adults with developmental dyslexia were avid readers as children and had a positive attitude toward reading and enjoyed reading. Although they had difficulties with basic and lower level reading skills their desire to learn more about a specific content area inspired them to persevere. Fink (1998) argues that:

> Through avid reading in a content area of high interest, these individuals with dyslexia developed knowledge of the specialized vocabulary, concepts, themes, questions, typical text structures, and critical issues of a particular field. Extensive reading about a favorite subject enhanced their background knowledge and enabled them to gain practice, which fostered fluency and development of increasingly sophisticated skills (p. 324).

It is possible, therefore, that one distinguishing characteristic of HPDDs is their positive attitude toward reading. In addition, the development of specialized vocabulary and content knowledge may explain why some developmental dyslexics are able to achieve academic success despite persistent phonological sensitivity difficulties.

Finally, it is necessary to understand the environmental influences that affect HPDDs. Samuelsson and Lundberg (1996) examined the impact environmental factors (i.e., home conditions, school conditions, and literacy environment) has on reading comprehension, spelling, word reading, and phonological processing. Samuelsson and Lundberg found that environmental factors influenced reading comprehension, spelling and word decoding. Since environmental factors may influence reading ability they may also have an impact on the appropriateness of using the discrepancy model for identifying dyslexia (Samuelsson & Lundberg, 1996). If environmental factors interact with behavioural and cognitive characteristics of individuals with dyslexia, then environmental factors should be controlled for during the diagnosis process.

## *Summary of Characteristics*

The examination of the characteristics of individuals with developmental dyslexia reveals that the phonological difficulties encountered by them persist into adulthood. Persistence of phonological difficulties may be attributed to their neurological basis. There is considerable amount of evidence suggesting that the brain of an individual with developmental dyslexia, in terms of language processing, does not function in the same manner as the brain of a normal reader. It could be assumed that if the brain is unable to process written material in a proper manner, then successful reading abilities could be unattainable. An inability to develop successful reading abilities, however, is not the case for all developmental dyslexics. Despite phonological difficulties and possible neurological deficits, some developmental dyslexics are able to obtain academic success. Thus, although the characteristics of an individual with developmental dyslexia provide a framework for understanding the difficulties he/she faces when reading, this framework does not provide an explanation why some individuals with developmental dyslexia are able to read at or above normal reading levels.

## Compensation

According to Salthouse (1995) compensation "refers to behaviour that develops either consciously or unconsciously to offset a real or imagined deficiency . . . compensation exists when the same, or a superior, level of proficiency on some criterion activity is achieved, despite deficiencies in one or more behavioural constituents of that activity" (p. 21). Thus, compensation can be viewed, in terms of developmental dyslexia, as the use of a strategy or behaviour that enables an individual with developmental dyslexia to read and/or comprehend text at average or above average levels despite deficiencies in phonological sensitivity. Salthouse (1995) stipulates that there are three types of compensation: (a) development or activation of substitutable skills, (b) investment of more time or effort, and (c) relaxation of the criteria (or standards or expectations) for successful performance, or adoption of different goals.

Salthouse's (1995) view of compensation can be expanded to incorporate HPDDs. First, the development or activation of substitutable skills implies that as individuals with developmental dyslexia can attempt to compensate for their reading difficulties by developing a cognitive strategy that enables them to by-pass their phonological difficulties. For example, rather than relying on decoding abilities, which is a weakness for individuals with developmental dyslexia, they may use contextual cues to identify a word, thereby by-passing a source of their reading difficulties. Secondly, individuals with developmental dyslexia may compensate for their reading difficulties through the investment of additional time and effort. Additional time to complete reading tasks is needed to use contextual cues and decoding strategies, which are time consuming processes. Finally, the relaxation of criteria and adoption of different goals suggests that individuals with developmental dyslexia may also compensate for their reading difficulties by changing their reading objective from being able to read individual words to being able to comprehend the meaning of the text. Thus, it is possible that individuals with developmental dyslexia may not just use one type of compensation, but rather, because of the complexity of the reading process, all three forms of compensation at once.

The question then arises as to whether it is appropriate to apply the term "compensated" to an individual with developmental dyslexia who has a reading accuracy level on par with normal readers. Salthouse (1995) would argue that "remediated" would be a more appropriate term because the deficit (ability to read) has been eliminated. This could be considered true if "the deficit is only relevant to the initial stage of learning, but not to later stages where other components become more important" (Salthouse, 1995, p. 24). When considering the reading acquisition models, for example, phonological processing may be considered only necessary at the beginning stages of learning to read. In the later stages, however, other strategies beyond phonology (e.g., sight vocabulary, context, topic familiarity, orthography, etc.) become available to the individual. Thus, although phonological processing may be considered important for learning to read, it may no longer be essential to the reading process once the individual can read. As a result, it could be argued that the term remediated may be more appropriate to describe a compensated developmental dyslexic because the skill of phonological processing no longer directly affects the individual's reading ability. This argument, however, is flawed. An individual with developmental dyslexia may have developed a strategy to eliminate a symptom, e.g., a reading accuracy problem, but the underlying problem still exists (e.g., difficulties with phonological processing). Therefore, if the coping strategy was removed, the difficulty would return. Overall, then, compensation is an appropriate term to apply to individuals with developmental dyslexia who are able to read at average or above average levels because not only does the underlying deficit continue to exist despite coping strategies that may be employed, but the deficit may also have other manifestations such as difficulty in learning a foreign language (Sparks, Ganschow, Kenneweg & Miller, 1991) or reduced reading speed (e.g., Hatcher et al., 2002; Parrila, Corkett, & Georgiou, 2004).

One of the problems when examining the application of the term compensation to individuals with developmental dyslexia is the fact that very little is known about how individuals with developmental dyslexia compensate for their reading difficulties when the strategies they use are internal (e.g., no external factors, such as having someone read the text, are used). Attempts have been made to explain reading difficulties encountered by individuals with developmental dyslexia through the application of theoretical models that have been developed to explain normal reading or the performance patterns observed in individuals with acquired dyslexia.

### *Compensation in Reading Acquisition Models*

In general, reading acquisition models propose that learning to read can be viewed as a developmental process whereby one's reading abilities evolve as one ages. In other words, reading is not the same for a beginning reader as it is for a proficient reader. The majority of reading models (e.g., Frith, 1986; Ehri, 1992, 1994; Spear-Swerling & Sternberg, 1996) begin with a logographic stage in which words are recognized based on visual cues, such as the shape of the letters in the word or its logo (e.g., the arches in the

MacDonald logo). At this stage, words are recognized on an individual basis and in isolation from other words. Following the logographic stage the beginning reader moves into the alphabetic stage that is characterized by the development of phonological processing abilities and the ability to isolate individual phonemes. It is during the alphabetic stage that readers begin to apply the knowledge they have gained about sound-to-letter associations to the development of grapheme-phoneme rules. Thus, a reader at this stage is able to sound out a new word. The final stage of most reading acquisition models is the orthographic stage. The orthographic stage is characterised by the use of both grapheme-phoneme correspondence and orthographic knowledge rather than just one or the other alone.

According to Ehri (1992, 1994), the beginning reader will read familiar words by relying on the visual cues present in a word, rather than on letter identities and sounds. When confronted with an unfamiliar word, the visual cue readers will use guessing in conjunction with context and will often confuse visually similar words. Furthermore, decontextualized word recognition is dependent upon decoding knowledge (Ehri, 1992). Ehri maintains that it is decoding knowledge that enables a reader to establish connections between a word's spelling and its pronunciation, which is stored in memory. It is this relationship that enables a word to be recognized automatically. Since individuals with developmental dyslexia are characterized by having poor decontextualized word recognition skills, poor phonological processing abilities and may rely on context as a reading strategy, it would appear that these individuals are stagnated at the alphabetic stage and as such will be unable to progress to the orthographic stage. This argument parallels Hatcher et al.'s (2002) position that individuals with developmental dyslexia are unable to compensate for their reading difficulties. Hatcher et al.'s position is based on their findings that dyslexic students in higher education continued to experience spelling, non-word reading, single word reading and phonological processing difficulties, as well as slower reading rates. The problem with Hatcher et al.'s position is that they are equating compensation with the mastery of specific underlying skills and not the end product of reading, which may be perceived as reading comprehension. Similarly, while Ehri's theory provides a clear picture of how these underlying skills support normal reading development, it does not provide an adequate explanation for why some individuals with developmental dyslexia can read at or above normal levels despite persistent problems in the underlying skills.

Unlike Ehri (1992, 1994), Spear-Swerling and Sternberg (1996) do not maintain that reading is an all-or-nothing phenomenon but that it is dependent upon the words, text and context of the material being read. While Spear-Swerling and Sternberg agree that phonological processing influences the acquisition of reading ability, they also maintain that repeated exposure to text also influences reading acquisition. Specifically, exposure to text helps the reader to remember the spelling of words and common letter strings. Thus an individual who has been previously exposed to words containing specific spelling patterns and letter strings should develop the ability to automatically recognize those words. However, according to Spear-Swerling and Sternberg, an individual does not have to rely solely on phonological processing to recognize a word. An individual can supplement or by-pass phonological processing by relying on context to facilitate word recognition. For example, in the sentence, "the boy sailed a toy boat" the word "boat" does not have to be decoded to be distinguished from the words "beat" and "boot" because the sentence context can be used to predict that the correct word is "boat"(Spear-Swerling & Sternberg, 1996, p. 94).

Finally, context also plays a role in the reading performance of a proficient reader. A proficient reader, according to Spear-Swerling and Sternberg (1996) is characterized by the ability to use higher-order processing, such as general knowledge of a topic and the topic's vocabulary, when reading. Therefore, Spear-Swerling and Sternberg argue that it is possible for an HPDD to comprehend text at the highest level if the topic and context of the text is familiar to them. When this is the case, the HPDD does not have to rely on phonological processing because they had previous exposure to the vocabulary of the topic and can use the familiar context to recognize words.

While Spear-Swerling and Sternberg argue that using contextual cues is a valid process in reading acquisition, they contradict themselves when they state that if a reader has not developed automatic word recognition skills, then the reader will not have the mental resources available for the development or application of comprehension strategies. Thus, although an individual may be able to read at normal levels when the topic is familiar, they cannot accomplish normal reading levels unless they have developed automatic word recognition skills. Therefore, the Spear-Swerling and Sternberg model suggests that some individuals with developmental dyslexia are able to read at or above normal levels because they have adequate topic knowledge. This strategy, however, will only be successful if they also have strong word recognition skills.

Finally, Frith's (1986) reading acquisition model acknowledges the possibility of compensation. Frith stipulates that even though an individual may not be able to progress to the next phase, the individual is still capable of making further advancement through the construction of compensatory strategies. That is, "if there is arrest along one particular path, compensation may take the form of over-development of an earlier strategy, but it may also take other forms. For instance, a child might be taught the behaviour that simulates the strategy that he or she was unable to acquire in the first place" (p. 73). Thus, advancement to the orthographic phase, for example, is "only possible because of the previous mastery of the alphabetic strategy. Again, we do not rule out – indeed we expect – that the well-adapted, and well-taught child can use something that resembles the orthographic strategy by way of compensation" (p. 74). Although Frith's model allows for the use of compensatory strategies as a mean of enabling individuals with developmental dyslexia to read at or above normal levels, she does not explain in any detail what compensatory strategies are used and how they are used.

The underlying problem with the aforementioned reading acquisition models is that they focus on automaticity[3] and, as a result, fail to explain reading in general (van der Leij & van Daal, 1999). That is, the above reading acquisition models view reading as the ability to recognize words quickly and accurately. Once an individual is able to recognize words quickly and accurately, the individual can be deemed as being able to read. A problem with this view is that word knowledge does not necessarily equal a reduction in reading speed (van der Leij & van Daal, 1999). For example, it has been found that when individuals with reading difficulties are given a list of words to learn and are given an opportunity to learn to accurately recognize the words, they will still read at a slower speed than normal readers (van der Leij & van Daal, 1999). In addition, viewing reading as a matter of automaticity suggests that the attention resources one uses decrease as automaticity increases until little or no attention resources are needed to recognize a word. Individuals with developmental dyslexia, as previously stated, read at a slower rate than normal readers regardless of word knowledge. This trait may be due to attention given not only to decoding words, but also to compensatory strategies, such as context usage. Overall, then, reading acquisition models may be able to indicate the point at which individuals with developmental dyslexia started to experience difficulties when learning to read, but they do not provide an account of how compensated developmental dyslexics do read.

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[3] Automaticity is "a mode of processing that is executed rapidly, free from demands on processing capacity, not subject to voluntary control, and not susceptible to interruption by competing activity in the same domain" (van der Leij & van Daal, 1999).

## *Compensation in Reading Process Models*

### *Dual-Route Model*

Attempts have been made to explain the reading process of developmental dyslexics in terms of the dual-route model, which stipulates that there are two distinct processes for reading words: the lexical and the sublexical. The lexical process requires accessing the mental representation of a word in memory. As a result, words are decoded through the use of memories of previously stored spellings of words (Aaron et al., 1998), which enables words to be automatically recognized based on their orthographic pattern (Berndt, Haendiges, Mitchum & Wayland, 1996; Bruck, 1998; Howard & Best, 1997; Lesch & Martin, 1998; Matthews, 1991; Pennington et al., 1987; Watson & Brown, 1992). Thus, spelling guidelines are stored in memory by "addresses" and "retrieved" as individual units resulting in a quicker and more automatic approach to word recognition.

The sublexical process relies on grapheme-phoneme-correspondence and decodes words using grapheme-phoneme (spelling-to-sound) rules (Aaron et al., 1998; Bjaalid et al., 1997; Brown, 1997), which is a time-consuming process. In general it has been found that individuals with developmental dyslexia experience a deficit in unfamiliar word and non-word reading (Aaron, 1987; Aaron et al., 1985; Ben-Dror et al., 1991; Brown, 1997) and this may be attributable to poor spelling-to-sound correspondence skills (Bruck, 1993a, 1993b).

Although it is now maintained that both routes are somewhat co-dependent, the lexical route is still perceived to be primarily used for processing exception words (words that do not follow grapheme-phoneme rules, e.g., have vs. save or gave), the sublexical route for processing non-words, and a combination of both routes is used for processing regular words (Bjaalid et al., 1997; Ben-Dror et al., 1991; Plaut, 1999). It has been argued that one of the distinctions between normal readers and dyslexics is that normal readers are proficient in both routes, while dyslexics are deficient in either one or both routes (Ben-Dror et al., 1991; Berndt et al., 1996).

Since individuals with developmental dyslexia experience poor phonological processing and difficulties with grapheme-phoneme correspondences, it is unlikely that they can use the sublexical route, which uses grapheme-phoneme correspondence, well enough to read printed material fluently. This implies that they must use the lexical route. The use of the lexical route would enable an individual with developmental dyslexia to automatically recognize a word based on its orthographic pattern. Their use of the lexical route can be assessed by examining their ability to recognize irregular words. Normal readers, regardless of age, experience more difficulty processing irregular words than regular words because the irregular words' orthographic patterns do not correspond to their correct pronunciation (Ben-Dror et al., 1991; Brown, 1997; Murphy, Pollatsek, & Well, 1988; Pennington et al., 1987); this is referred to as a regularity effect. It would be logical to assume that individuals with developmental dyslexia should display little, if any, regularity effect because of their difficulty using grapheme-phoneme processing. That is, since an irregular word (e.g., have) cannot be pronounced correctly using only grapheme-phoneme conversion, an individual must access the word directly from the lexicon. As individuals with developmental dyslexia already experience poor grapheme-phoneme processing, it can be theorized that they rely on visual word processing. If the lexical route is already well developed in individuals with developmental dyslexia, then they should be able to use it equally well when reading irregular words and regular words. This has not been proven to be the case. What has been found is that individuals with developmental dyslexia, like normal readers, do show a regularity effect (Ben-Dror et al., 1991; Brown, 1997; Metsala, Stanovich, & Brown, 1998). Therefore, the dual route model does not adequately explain how HPDDs read.

### *Word Recognition in Connectionist Models*

The most recent challenge to the dual route model is connectionism. Connectionism "provides a set of concepts and techniques which may be put together in various ways to construct a computational model . . . A fixed arrangement of the pieces that allow intelligent behaviour" (Cooper, 1996, p. 50). Cooper goes on to describe the connectionist network as follows:

> The nodes interact via the flow of activation along the connections, which are generally directed (so activation flows from one node to another, but not back)

> and also have a number attached to them. This number, the weight of the connection, determines the strength and nature of the interaction between nodes . . . The weight is thus a measure of the correlation between two nodes, but in general any node will be simultaneously excited and inhibited by many other nodes, with the activation of each node being given by some function of the weighted sum of its inputs (p. 34).

In other words, connectionist models are built on the premise that the learning process consists of processing devices called nodes or units that become either active or inactive according to the stimulation received (McClelland & Rumelhart, 1981). This pattern occurs across the system regardless of the number of units it contains (Underwood & Batt, 1998; Seidenberg & McClelland, 1989; Cooper, 1996). In the construction of a connectionist model that pertains to reading, the units consist of the skills used in reading such as orthographic and phonological units (Seidenberg & McClelland, 1989); however, the presence of hidden units (any unit that is not an input or output unit) is found in the majority of connectionist models. Through the use of hidden units, connectionist models are able to mimic human cognitive processes by using a controlled set of input units and then examining their impact on the network's ability to perform the desired cognitive task, e.g., word recognition (Underwood & Batt, 1998; Cooper, 1996). The use of hidden units enables the researcher to observe, in a controlled environment, the growth in the reading process from an inability to read to an expert word reader.

Harm and Seidenberg's (2001) connectionist model is developed on the premise that orthography and phonology are connected. They stipulate that the orthographic difficulties encountered by individuals with developmental dyslexia "arise from a phonological impairment whose effects depend on properties of the orthographic input" (p. 75). Thus, they attempt to explain the reading difficulties encountered by developmental dyslexics by restricting their model's ability to represent phonology. They maintain that by repressing the model's ability to represent phonology it would mimic the phonological difficulties encountered by individuals with developmental dyslexia. Their model, however, has two main flaws in relation to high-functioning adult dyslexics.

First, the model does not develop segmental phonological representations as it processes printed material based on the visual similarity of a pseudohomophone to a real word. The lack of segmental phonological representations suggests that the model mimics a whole word reader or a visual analogy reader and does not address how novel words would be read. Secondly, since Harm and Seidenberg's (2001) model focuses on the ability of the developmental dyslexic to read non-words, it does not explain the regularity effect displayed by developmental dyslexics. In order to explain why developmental dyslexics display a regularity effect, Harm and Seidenberg's model must be expanded to consider how exception words are read.

Thus, progress still needs to be made in the development and/or refinement of reading process models for them to adequately explain how some individuals with developmental dyslexia are able to read at or above normal levels despite persistent problems in underlying cognitive processes. A contributing factor to this inadequacy may be the fact that reading models are focussed on decontextualized word reading and not on contextualized word reading. Furthermore, current models focus on the reading difficulties of individuals with developmental dyslexia and not on their ability to use compensatory strategies. The ideal model, yet to be proposed, should take into account how compensatory strategies can contribute to the reading process.

### *Context as a Compensatory Strategy*

A significant number of students with developmental dyslexia are able to pursue a post-secondary education and show unexpectedly high levels of comprehension when compared to their word recognition performance. One possible explanation for this phenomenon is that while students with developmental dyslexia have inadequate decontextualized word recognition or decoding skills, this inadequacy is compensated for by a better use of contextual cues when relevant context is provided (Bruck, 1990; Nation & Snowling, 1998). Nation and Snowling (1998) found that verbally providing context improved the accuracy of visual word recognition in children with developmental dyslexia more than in normal readers. Furthermore, Fink's (1996) qualitative research with HPDDs indicated that they relied on context when reading. Fink's participants reported that this compensatory strategy was developed and used in childhood and continued to remain as their key compensatory strategy.

Adults with developmental dyslexia, similar to children with developmental dyslexia, rely on context to a greater degree than normal readers as a means to assist in word recognition (Aaron, 1989; Bruck, 1998). Aaron (1989) hypothesized that since children with developmental dyslexia may be prone to directly accessing the semantic lexicon rather than using the phonology of the words they will be more successful in reading content words and meaningful texts than reading function words or passages void of contextual cues. Aaron found that like children with developmental dyslexia, adults with developmental dyslexia experience difficulty when reading function words and context-free passages. This finding suggests that "meaning and context rather than phonology facilities the developmental dyslexics' reading performance" (Aaron, 1989, p. 305). A weakness in Aaron's study is the fact that the adult dyslexic group consisted of only six participants. In addition, while Aaron's study examined the influence of the removal of contextual cues, his study did not address what aspects of context influenced the participants' performance.

Ben-Dror et al. (1991), like Aaron (1989), examined whether adults with developmental dyslexia use context to a greater degree than skilled readers. However, unlike Aaron (1989), Ben-Dror et al.'s study included 20 adults with developmental dyslexia and they used three contextual conditions: neutral context, congruous context and incongruous context. By using reaction time as the dependent variable, Ben-Dror et al. found that the dyslexic group, chronological age-match control group, and the reading age-matched control group all exhibited effects of context; however, the effects were larger for the dyslexic group and the reading age-matched control group than for the chronological age-match control group. Overall, Ben-Dror et al. concluded that developmental dyslexics' reliance on context increased in parallel with word difficulty. As a result, individuals with developmental dyslexia may develop stronger contextual processing skills because of their continual reliance on this compensatory strategy. According to Bruck (1998), however, the reliance on context is not an efficient coping strategy as it does not sufficiently increase reading speed and comprehension. In addition, reliance on context to assist in word recognition decreases working memory capacity and word prediction (Brosnan et al., 2002).

There are two main problems with Bruck's (1998) statement. First, Bruck's position that "reliance on context to aid word recognition is often a liability" (p. 182) was not addressed in her study. That is, Bruck's tasks were not designed to determine whether context can play an inhibitory as well as a facilitatory role. Second, Bruck's suggestion that a slow reading speed may negatively affect comprehension abilities is countered by Jackson's (2003) research. Jackson found that when there is no demand on reading speed, the ability to comprehend standard texts is not significantly related to word decoding accuracy or reading speed among university students who are normal readers. In addition, Jackson found that word decoding accuracy and reading speed are not related to academic success and that text comprehension ability is only minimally related to academic success. Based on Jackson's research, it would seem that Bruck's concern about slow reading speed may be unfounded.

A possible explanation for how context can be used as a compensatory strategy is offered by Rumelhart's schema[4] theory (Driscoll, 1994). According to Rumelhart's schema theory, our ability to comprehend or understand what the we reads is influenced by our prior knowledge and experiences (Driscoll, 1994; Fink, 1996). Thus, reading is influenced by what the reader knows and the reader's ability to access relevant schema from long-term memory (LTM) (Driscoll, 1994; Fink, 1996). If an individual is reading new information that is unfamiliar to him/her, the individual must a develop new schema before comprehension can occur. It may be theorized, therefore, that normal readers' contextual processing increases as familiarity of the topic decreases because the readers are building new schema to assist their understanding. Once a schema for that topic is developed, a decrease in context processing will occur. It may be possible that some developmental dyslexics are able to become successful academically because they develop numerous schemata in a particular field (e.g., engineering). Support for this belief may be found in Fink's (1996) interview data, which she interpreted as indicating that

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[4] "A schema is a data structure for representing the generic concepts stored in memory" (Driscoll, 1994, p. 144).

> through focussed reading in highly specialized disciplines, they [dyslexics] developed deep background knowledge and became conversant with domain-specific vocabulary, concepts, themes, questions, and typical text structures. Schema familiarity provided the scaffold that supported their development of optimal skills (p. 276).

In addition, since schemas may be defined as precompiled knowledge structures that are stored in LTM and accessed to support comprehension, it is possible for a schema to function as a prime in word recognition because the components of the schema achieve a higher than normal activation once the schema itself has been activated (Traxler, Foss, Seely, Kaup, & Morris, 2000). For example, if a reader recognizes that the story is about fire fighters, the reader will access the schema containing their knowledge about fire fighters, which in turn activates key related concepts such as fire engines, water, burning buildings, etc. All of these related words would then likely be recognized faster in the remaining text.

In lexical decision tasks, when a target word (e.g., doctor) is preceded by a prime that has a high association with the target word (e.g., nurse), the response is quicker and more accurate than when the target word is paired with an unrelated prime (e.g., chair). This quicker and more accurate response is referred to as the associative priming effect and has been verified repeatedly in both naming and lexical decision tasks (Pecher & Raaijmakers, 1999; Thompson-Schill, Kurtz & Gabrieli, 1998; Walenski, 2003) and underlies two theories of priming: spreading activation and compound-cue retrieval (Charwarski & Sternberg, 1993; Pecher & Raaijmakers, 1999; Thompson-Schill et al., 1998; Walenski, 2003). Spreading activation refers to the activation of words through a network of interconnected words in LTM (Traxler et al., 2000; Walenski, 2003). This activation spreads through all of the related words, which are activated for a limited period of time. During their activation period, if a related target word is presented, the response to this item is facilitated with the strength of facilitation depending upon the strength of the relationship between the target and the prime (Charwarski & Sternberg, 1993). Compound-cue retrieval states that the prime combines with the target to form a joint retrieval cue. It is because of this compound cue that semantically associated prime-target pairs are more easily retrieved from LTM than non-associated prime-target pairs (Charwarski & Sternberg 1993; Walenski, 2003). That is, response to the target word is facilitated when the prime and the target are associated in memory because the overall familiarity of the prime-target pair is higher when they are connected in memory than when they are not connected (Charwarski & Sternberg, 1993, p. 96).

In terms of comprehension therefore, while individuals with developmental dyslexia may rely on context to a greater degree than individuals without reading difficulties, this reliance increases in parallel with word difficulty. Furthermore, when time restraints are removed comprehension abilities of individuals with developmental dyslexia's do not appear to be affected by their weak phonological processing. This may be due to the fact that the effectiveness of context as a compensatory strategy is tied to readers' prior knowledge and experiences, which form the foundation of their schemas. That is, in priming tasks, context may increase the comprehension of individuals with developmental dyslexia because their schemas are activated by the primes through either spreading activation or compound-cue retrieval.

### *Interactive and Modular Theories of Word Reading*

Reading process models and context usage can be combined to explain how unknown and ambiguous words are resolved. When a reader encounters an unknown or ambiguous word lexical ambiguity is resolved through two processes: lexical access and post-access integration (Twilley & Dixon, 2000). Lexical access involves being able to recognize a word and its correct meaning through the use of mapping perceptual information onto lexical representations (Berndt et al., 1996; Bruck 1998; Howard & Best, 1997; Lesch & Martin, 1998; Matthews, 1991; Pennington et al., 1987; Twilley & Dixon, 2000; Watson & Brown, 1992). Thus, lexical access uses perceptual information from the environment, such as a word's orthographic pattern, to recognize a word. On the other hand, post-access integration process involves combining lexical representations with relevant internal information, for example schemas (Twilley & Dixon 2000). Therefore, during the post-access integration process, the visual representation of a word interacts bi-directionally with context to activate the correct meaning of a word.

Lexical access and post-access integration are used to suggest the temporal locus of context effects within the modular and interactive (non-modular) theories of language processing, respectively (Sereno, Brewer & O'Donnell, 2003, p. 328). The modular theory of language processing proposes that there are individual and separate structures or modules that operate independently of each other (Potter, Moryadas, Abrams & Noel, 1993; Sereno et al., 2003; Twilley & Dixon, 2000; Vigliocco & Hartsuiker, 2002; Vu, Kellas, Metcalf & Herman, 2000). For example, the lexicon may be regarded as one module and context processing as another. The modular approach to ambiguity resolution is considered context-independent because information flows in one direction from one module (lexicon) to the next (context processing) without any interaction (Paul, Kellas, Martin & Clark, 1992; Twilley & Dixon, 2000). Due to this lack of interaction, context effects are attributed to lexical priming alone. Lexical priming refers to the associative relationships between words in the lexicon, which are affected by spreading activation (Twilley & Dixon, 2000). For example, when a target word is preceded by a sentence prime, the target may be facilitated by the individual words (i.e., nouns and verbs) in the sentence because these words have an existing semantic relationship, already represented in the lexicon, with the target word (Stanovich & West, 1981; Walenski, 2003). As a result, any sentence containing those words would facilitate the recognition of the target word because all words associated with the target word would be activated (Duffy, Henderson & Morris, 1989; Twilley & Dixon, 2000; Walenski, 2003). Therefore, when a word is encountered, all possible associations of the word are activated, regardless of the context. It is only after the activation of all the associated words that context is used to select the correct word and inhibit all other words. In the modular theory of language processing, therefore, there is no interaction between lexical access and post-access levels (Twilley & Dixon, 2000).

On the other hand, a non-modular or interactive approach to language processing may be used to resolve lexical ambiguity. The interactive theory postulates that there is a bi-directional interaction between lexical access and post-access processes (Paul, Kellas, Martin & Clark, 1992; Potter et al., 1993; Sereno et al., 2003; Twilley & Dixon, 2000; Vigliocco & Hartsuiker, 2002; Vu et al., 2000). According to the interactive theory, when a word or an ambiguous word is encountered, the preceding context influences the lexical access by activating only the contextually appropriate meaning and inhibiting all other meanings (Twilley & Dixon, 2000). As a result, spreading activation occurs through the integrated syntactic relationship between the main noun and verb and the context of the sentence and facilitates the recognition of a word (Duffy et al., 1989; Stanovich & West, 1981, 1983). In this case, a sentence context can prime a target word even if no single word in the sentence has an existing semantic relationship with the target word (Paul et al., 1992; Stanovich & West, 1981, 1983; Twilley & Dixon, 2000). Thus, it is the meaning of the sentence and not the relationship between the target word and individual words in the sentence that is doing the priming.

Experimental support has been found for both the modular and the interactive theories of language processing; however, context strength and meaning frequency may explain the conflicting results (Twilley & Dixon, 2000). In Twilley and Dixon's (2000) review of 20 years of lexical ambiguity research, they discovered that the studies in which "a homograph was preceded by a strongly biasing sentence, only the contextually appropriate interpretation was primed" thereby supporting the interactive approach to language processing (p. 55). On the other hand, "when a homograph was preceded by a sentence context that was weakly biased toward the low-frequency [subordinate] meaning, both interpretations of the homograph were primed equally", which suggest a modular theory of language processing (p. 55). Twilley and Dixon also found that faster response times were generated when the prime was related to the high-frequency [dominant] meaning of the homograph rather than to the low-frequency meaning. These results suggest that meaning activation is affected by both context strength and meaning frequency. Although the debate between modular and interactive theories remains (Sereno et al., 2003), no research has been conducted to determine which theory would be most appropriate for describing the point at which context influences meaning activation and word recognition in individuals with developmental dyslexia.

## The Purpose of the Current Research

Although there is extensive research into the reading abilities of children with developmental dyslexia, much less research has examined these abilities in adults with developmental dyslexia and very few of those have focussed on HPDDs. As a result, there is a lack of knowledge about how HPDDs are able to read at par with their academic peers. The current research will address the gap in the literature pertaining to the specific aspects of context that are used by HPDDs to assist word recognition. Previous research indicates that meaning and context are aids used by adults with developmental dyslexia (e.g., Aaron, 1989; Ben-Dror et al., 1991). However, additional research is needed to determine how context is used by HPDDs. Although Ben-Dror et al.'s (1991) manipulation of the nature of the context sentence prime (neutral, congruent and incongruent) in relation to the target word, was the first step toward understanding how context is used by individuals with developmental dyslexics, additional manipulations are necessary. For example, do developmental dyslexics rely solely on the meaning of the sentence or do syntactic cues play an important role?

Three experiments were conducted to address how HPDDs differ from normal adult readers in (a) how a sentence context prime affects the lexical access process, (b) how sensitive the initial meaning activation of the homograph is to the prior context, (c) how the presentation of two words (the prime and the target) in the same story creates a contextual connection between them when they are otherwise not semantically related, and (d) the effect of overall contextual salience. By addressing these areas it may be possible to further understand whether the modular or interactive model of language processing best describes the how HPDDs use context to aid their word recognition process.

# CHAPTER 3:

## EXPERIMENT 1

Experiment 1 examines how a sentence prime affects the lexical access process. By using sentence primes that have either (a) congruent, (b) incongruent, (c) subject-verb disrupted, (d) subject-verb neutral, or (e) subject-verb preserved relationship with the target word, Experiment 1 aims to answer the following questions:

1. Is the facilitation effect generated by a congruent context different for high-performing developmental dyslexics and normal adult readers?
2. Is the inhibition effect generated by an incongruent context the same for both groups?
3. Do the groups react differently to the manipulation of syntactic structure?

According to Duffy et al. (1989), much of the controversy regarding context effects has focused on the issue of whether the context effects that have been observed reflect an influence on lexical access or on some process that follows lexical access. If context reflects a post-access process, then an inhibition effect would be found in the incongruent condition. An inhibition effect would occur because the individual is having difficulty integrating the target word with a sentence that has no semantic relationship to the target word (Duffy et al., 1989). That is, inhibition is speculated "to occur in a priming paradigm when attentional processes, such as those associated with conscious prediction of the target word, are engaged" (Duffy et al., 1989, p. 794). On the other hand, if no inhibition is found in the incongruent condition, then it can be argued that the possible facilitation effect is lexical (for example, a specific word in the context primes the target word) rather than post-lexical.

Recall that the modular, or context-independent, model of language processing suggests that information flows in one direction from one module to the next without interaction (Duffy et al., 1989; Hopkins, Kellas, & Paul, 1995; Paul et al., 1992; Sereno et al., 2003; Twilley & Dixon, 2000). The modular model of language processing predicts that all possible meanings of an ambiguous word are initially activated when the word is encountered. The meaning that has the greatest semantic congruency with the context is then selected post-lexically and the remaining meanings are suppressed (Hopkins et al., 1995; Paul et al., 1992). The lack of interaction between modules suggests that lexical access itself is not affected by the context.

In contrast, interactive models of language processing argue that information is processed in either a context-dependent or a context-sensitive manner (Paul et al., 2004) because lexical access is guided by the prior context (Duffy et al., 1989; Hopkins et al., 1995; Paul et al., 1992; Potter et al., 1993; Sereno et al., 2003; Twilley & Dixon, 2000; Vigliocco & Hartsuiker, 2002; Vu et al., 2000). The context-dependent view argues that only the contextually constrained meaning of a word is activated whereas the context-sensitive view suggests that several meanings may be activated but the contextually appropriate meanings are activated more strongly (Paul et al., 1992).

In terms of Experiment 1, when facilitation occurs in a condition that contains a congruent sentence prime, both modular and interactive models of language processing can explain the results but differ in terms of the role of the integrated sentence level representations in the process. Modular models argue that an integrated sentence level representation is not able to facilitate lexical access. In a modular model, facilitation can result from lexical-lexical priming, that is, context contains a single word (e.g., barber) that is semantically associated with the target word (e.g., hair) to the extent that the target word is primed. Alternatively, "combination" (Duffy et al., 1989) lexical-lexical models allow for the possibility that the sentence contains several words that are modestly related to the target word but can jointly prime it. For example, the context sentence can contain a noun and a verb (e.g., barber and trim) that have a modest semantic relationship with the target word (e.g., mustache). According to combination lexical-lexical models, any sentence, regardless of syntactic structure, containing the words *barber* and *trim* would facilitate the activation of the word *mustache* (Duffy et al., 1989).

In an interactive model of language processing the occurrence of facilitation in a congruent sentence context is attributed to the integrated sentence level representation. The interactive model of language processing predicts that manipulation of the syntactic relationship of the main noun and verb of the sentence should affect facilitation (Duffy et al., 1989).

By examining how context facilitates or inhibits word recognition, Experiment 1 will provide additional insight into the word recognition process used by high-performing developmental dyslexics. In the current experiment, the focus is on examining whether high-performing developmental dyslexics show the same pattern of performance across different conditions as the control group. Previous studies have indicated that modular combination models can explain the performance of normally reading participants (Duffy et al., 1989). If this is the case, then we would expect that congruent, subject-verb disrupted, and subject-verb preserved contexts would all facilitate the performance equally. In addition, there should not be a significant inhibition effect.

In contrast, West, Stanovich, and Cunningham (1995, p. 276) argued that "as a reader's word recognition processes decrease in efficiency, there is a tendency for the reader to rely more on prior textual and sentential context to aid in lexical access." If this is the case, then we would expect a larger facilitation effect in the congruent and subject-verb preserved conditions than in the subject-verb disrupted condition. This pattern of results would favour interactive models of language processing.

## Method

### *Participants*

The experimental group (RD) consisted of 25 participants (10 males and 15 females) who reported a significant history of reading difficulties and whose performance on the elementary education section of the modified Adult Reading History Questionnaire (Parrila, Corkett, Kirby & Hein, 2003; see below for details) indicated reading difficulties in childhood. The average age of the RD participants was 30.00 (*SD* = 9.37). The RD participants were all either current university students or recent graduates (less than six months at the time of initial testing) and were recruited through letters sent by the university's Student Support Services, announcements in undergraduate classes and posters displayed throughout the University's campus.

The control group (ND) consisted of 31 participants (10 males and 21 females) who reported no history of reading problems. The average age of the ND participants was 25.03 (*SD* = 6.26). The ND group was recruited through announcements in undergraduate classes and through posters displayed throughout the University's campus. All were current university students.

## *Tasks*

### *Questionnaire*

Both groups were asked to complete a questionnaire that required the participants to report their (a) demographic information; (b) their reading, spelling and educational experiences at the elementary, secondary and post-secondary level; and (c) their use of various reading, writing, learning, study, and test-taking strategies at the elementary, secondary and post-secondary level. They had the option of bringing the questionnaire home to complete or to complete it in the lab.

The questionnaire consisted of three main parts. The first part of the questionnaire requested demographic information. The second and third parts of the questionnaire were divided into three sections: (a) elementary education, (b) secondary education, and (c) post-secondary education. The second part of the questionnaire consisted of a modified Adult Reading History Questionnaire (Lefly & Pennington, 2000). A modification of the Adult Reading History Questionnaire was necessary as the original questionnaire does not distinguish between levels of education, e.g., elementary, secondary and post-secondary education. The lack of segregation between levels of education could significantly underestimate the reading acquisition problems of high-performing developmental dyslexics because they may have later successfully compensated for their reading difficulties. The revised questionnaire poses parallel questions at each level of education to determine (a) at what point during their education the participants possibly experienced reading difficulties, and (b) at what point during their education they no longer experienced reading difficulties.

The elementary education section of the modified Adult Reading History Questionnaire was used to determine the presence of a significant history of reading difficulties and contained 12 questions pertaining to the participant's reading, spelling, and educational experiences (see Appendix A). Each question required a response on a Likert scale from 0 to 4, with the higher numbers corresponding to less favourable responses. The participants' scores were calculated by dividing their total score by the maximum score (48). Thus, the smallest possible score was 0 and the highest was 1. Reliability (alpha) was .90.

### *Standardized Tests*

A battery of standardized tests was administered to all participants. The battery consisted of Standard Progressive Matrices, Peabody Picture Vocabulary Test – III (PPVT-III), Peabody Individual Achievement Test-Revised (PIAT-R) - Spelling Recognition, Wide Range Achievement Test 3 (WRAT3) - Spelling, Nelson-Denny Reading Comprehension, and the Word Identification and Word Attack subtests from the Woodcock Reading Mastery Test – Revised (WRMT-R).

*Intelligence.* An abbreviated form of the Standard Progressive Matrices (Raven, 1976) was given as a measure of non-verbal intelligence. Previous research (e.g., Ablard & Mills, 1996; Arthur & Day, 1994; Arthur, Tuber, Paul, & Sanchez-Ku, 1999; Bors & Stokes, 1998) has indicated that abridged versions of the Raven's Matrices have psychometric properties that are not significantly different from the long form. Therefore, for the purpose of this study all of sections C, D, and E were given.

The PPVT-III (Dunn & Dunn, 1997) was administered to provide an estimate of the participants' verbal intelligence. The PPVT-III was administered in the standard format except for the following two variations. First, all the words were recorded using GoldWave digital sound recording program and programmed into the DirectRT (v2003; Empirisoft, 2003) reaction time software for presentation. This ensured consistency in the pronunciation of the target words across all participants. Second, rather than pointing to the picture that corresponded to the given target word, the participant responded by pressing a key on a number pad that was labelled to correspond with each sector of the PPVT-III matrix and then pressed ENTER to play the next target word. The PPVT-III easel was placed facing the participant and the experimenter turned the pages.

*Spelling.* The PIAT - Spelling Recognition (Markwardt, 1989), was administered by displaying the word choices, as they appeared in the test protocol, on a computer screen with the help of DirectRT software. The participant selected the correct spelling of the word by using the number pad that was coded to correspond with each of the choices. In addition, the Blue form of Wide Range Achievement Test (WRAT3) – Spelling (Wilkinson, 1993) subtest was administered following the standard administration procedures with the exception that all participants were presented all the words.

*Word Reading.* Both the WRMT-R (Woodcock, 1987) Word Attack and Word Identification tests were presented separately on a computer with the help of DirectRT software. For both subtests the letter string would appear in the centre of the screen. Once the participant pronounced the letter string into a microphone, the letter string was replaced with a +, which also appeared in the centre of the screen. The experimenter then recorded the accuracy of the response by pressing the appropriate number pad key. Once the experimenter pressed the number pad key, the next letter string would appear.

*Reading Comprehension.* The comprehension section of the Nelson-Denny Reading Test (Brown, Fishco, & Hanna, 1993) was administered in pen-and-paper format and following the standard 20 minute administration procedures outlined in the test's manual. Both reading rate and comprehension scores were obtained.

### *Experimental Task*

*Word Reading in Context.* To examine the specific aspects of context that facilitate word recognition, 100 sentence primes and 100 target words from Duffy et al. (1989) were used. The sentences were presented on the screen in black letters against a white background in random order. Each sentence prime included a subject noun and a verb, which had a varying association with the target word. Each sentence prime and their corresponding target words (see Appendix B) were equally divided into the following five context conditions:

1. The congruent (C) condition included a subject noun and verb that were highly associated with the target words. Example: The wine was served from the *decanter*.
2. The incongruent (IC) condition consisted of the same sentences from the congruent condition, but the target words were randomly re-paired with the sentences so that a nonsensical completion of the context was formed. Example: The politician appealed to the *decanter*.
3. The subject-verb disrupted (SVD) condition was created by changing the relationship between the critical noun and the verb so that the noun was no longer the subject of the verb. For the majority of sentences an additional noun or

pronoun was added to act as the new subject of the verb. Example: Juice replaced the wine and was served from the *decanter*.

4. The subject-verb neutral (SVN) condition was created by replacing the subject noun and the verb from the congruent context with neutral words. Example: The stuff was placed near the *decanter*.
5. The subject-verb preserved (SVP) condition consisted of preserving the original relationship between the noun and verb. If any additional words were added to the sentence in the subject-verb disrupted condition, these words remained in the sentence. Example: Juice replaced the wine which was served from the *decanter*.

The same target words were used in each of the five context conditions. The targets were matched in terms of frequency of occurrence in the English Language (Kucera-Francis frequency; MRC Psycholinguistic Database, 1987), bigram frequency, number of letters, and number of syllables. Appendix C displays the descriptive measures for each target word.

The task was presented in the following sequence: (a) the participant silently read the sentence and pressed the "enter" key when he/she had finished reading the sentence; (b) the sentence was then removed from the screen; (c) the target word, in small letters, appeared immediately in the centre of the screen; (d) the participant named the target words as quickly and accurately as possible. The target remained on the screen until the participant responded and DirectRT recorded the voice onset reaction time. After the response the experimenter recorded, by pressing one of two number pad keys, whether the participant responded correctly or not and once the experimenter pressed the appropriate key, the next sentence appeared on the screen.

## Results

### *Descriptive Analyses*

The elementary education section of the modified Adult Reading History Questionnaire was used to determine the presence of a significant history of reading difficulties and contained 12 questions pertaining to the participant's reading, spelling, and educational experiences. The mean score for the RD group was .56 (*SD* = .12; min = .37 and max = .70) and the mean score for the control group was .17 (*SD* = .08; min = .00 and max = .29). The groups were selected so that there was no overlap between the scores in the two groups.

The mean (standard deviations in parenthesis) age and results from the standardized tests are presented in Table 3-1. Standardized scores are shown for all other tasks except Raven's Standard Progressive Matrices. Raven's Standard Progressive Matrices score was obtained by adding the number of correct responses in sections C, D and E to the total number of items in sections A and B. Due to the simplicity of the items in sections A and B, it was assumed that all participants would be able to respond to these items correctly. Table 3-1 also includes results from analysis of variance comparing the raw scores of the two groups on these tasks.

As indicated in Table 3-1, RD participants had greater difficulty than the ND participants with Raven's Standard Progressive Matrices, $F$ (1, 54) = 5.55, $p$ = .022, but not with PPVT-III, $F$(1, 54) = 2.09, $p$ = .154.

Table 3-1

*Characteristics of RD and ND Participants*

| | Groups | | | | |
|---|---|---|---|---|---|
| | RD<br>(*n* = 24) | | ND<br>(*n* = 31) | | |
| | Mean | *SD* | Mean | *SD* | *F* |
| *Age* | 30.00 | 9.37 | 25.03 | 6.26 | 5.62$^{*}$ |
| *Intelligence* | | | | | |
| Raven's Matrices[1] | 54.88 | 3.00 | 56.52 | 2.19 | 5.55$^{*}$ |
| PPVT-III[2] | 105.46 | 7.64 | 113.32 | 11.63 | 2.09 |
| *Spelling* | | | | | |
| PIAT-R[2] | 92.29 | 9.61 | 100.84 | 11.35 | 13.18$^{**}$ |
| WRAT3[2] | 96.95 | 16.83 | 113.43 | 10.22 | 27.87$^{***}$ |
| *Word Reading* | | | | | |
| Word Identification[2] | 99.42 | 6.85 | 112.48 | 7.41 | 32.19$^{***}$ |
| Word Attack[2] | 96.79 | 11.52 | 109.06 | 9.23 | 24.69$^{***}$ |
| *Reading Comprehension* | | | | | |
| Nelson-Denny[2] | 222.67 | 21.10 | 232.16 | 15.08 | 6.38$^{*}$ |
| *Reading Rate* | | | | | |
| Nelson-Denny[2] | 202.45 | 31.91 | 219.55 | 27.96 | 7.21$^{**}$ |

*Note.* [1] = raw score; [2] = standard score. RD = participants with a history of reading difficulties; ND = participants with no history of reading difficulties; PPVT- III = Peabody Picture Vocabulary Test – III, PIAT-R = Peabody Individual Achievement Test – Spelling recognition subtest; WRAT3 = Wide Range Achievement Test- Spelling subtest; Word Identification = Woodcock Reading Mastery Test – Revised - Word identification subtest; Word Attack = Woodcock Reading Mastery Test – Revised – Word attack subtest; Nelson-Denny = Nelson-Denny Reading Test
$p < .05^{*}$ $p < .01^{**}$ $p < .001^{***}$

The RD participants were poorer than the ND participants at recognizing the correct spellings of words (PIAT-R), *F*(1, 54) = 13.18, *p* = .001, as well as in writing the correct spelling of words (WRAT3) to dictation, *F*(1,53) =27.87, *p* = .000. The standard score mean of 92.29 on the PIAT-R and 96.95 on the WRAT3 corresponds to a grade ten equivalency and high school equivalency, respectively. The RD group's performance on these tasks parallels previous research (e.g., Curtin et al., 2001; Bruck 1993a) indicating that individuals with developmental dyslexia have persistent spelling difficulties.

Analysis of variance with the Word Identification and Word Attack raw scores indicated that the RD participants had more difficulty both naming real words, $F(1, 54) = 32.19$, $p < .001$, and decoding pseudowords, $F(1, 54) = 24.69$, $p < .001$, than the ND participants. The standard score means of 92.42 for Word Identification and 96.79 for Word Attack both correspond to a grade nine equivalency. These results support earlier studies (e.g., Aaron, 1989; Lefly & Pennington, 1991; Gallagher et al., 1996) indicating that adults with developmental dyslexia continue to experience problems with decoding and decontextualized word reading.

Finally, RD participants had significantly lower comprehension scores than the ND participants, $F(1, 54) = 6.38$, $p = .015$, in Nelson-Denny when standard administration procedures (20 minute time limit) were followed. In addition, RD participants were significantly slower readers than the ND participants, $F(1, 54) = 7.21$, $p = .010$. The standard scores of 232.16 and 222.67 correspond to 64th and 50th percentile using end of 2nd-year University norms. When the time factor was removed and a percentage of correct responses was calculated, the difference between the RD participants ($M = 85.16$, $SD = 10.23$) and the ND participants ($M = 88.77$, $SD = 9.02$) was no longer significant, $F(1, 54) = 1.97$, $p = .166$. This finding suggests that when time restraints were removed, the RD participants' comprehension rates are similar to those of the ND participants. In other words, our participants could be described as compensated in the level of untimed reading comprehension.

In sum, there were significant differences between the RD and ND participants' performances on the decoding, word reading, spelling, and non-verbal reasoning tasks. Although there was a significant difference in the initial reading comprehension score, the difference in comprehension was no longer significant when the time factor was removed. There was no significant difference between the RD and ND participants' vocabulary knowledge. The aforementioned characteristics of the RD participants largely replicate previous research, which has found that while high-performing developmental dyslexics perform at par with normal readers on most cognitive ability and comprehension tasks (e.g., Helenius, Salmelin, Service & Connolly, 1999; Jackson & Doellinger, 2002; Mosberg & Johns, 1994), they do not perform at par on word reading and/or spelling tasks (e.g., Hatcher et al., 2002; Rack, 1997; Ransby & Swanson, 2003). In addition, the characteristics of the RD participants lend support to research suggesting that poor decoding and spelling do not necessarily lead to poor untimed reading comprehension in University students (Jackson, 2005). According to Jackson, high-performing developmental dyslexics can be expected to have comprehension skills at par with normal readers when time restraints are removed.

### *Experimental Task*

All reaction times that corresponded to an inaccurate response were removed before the data were analyzed. Specifically, the RD participants made a total of 15 errors in the congruent condition, 18 errors in the incongruent condition, 15 errors in the subject-verb disrupted condition, 16 errors in the subject-verb neutral condition, and 17 errors in the subject-verb preserved condition. The ND participants made a total of 4 errors in the congruent condition, 6 errors in the incongruent condition, 5 errors in the subject-verb disrupted, 5 errors in the subject-verb neutral, and 4 errors in the subject-verb preserved condition. Overall, inaccurate responses constituted 1.94% of the data. In addition, machine errors (deemed as reaction times below 200 ms or above 5000 ms) were also removed before the data were analysed. Overall, the machine errors constituted 10.37% of the naming speed data. Table 3-2 displays the groups' means, standard deviations, minimum and maximum reaction times, and facilitation for each condition. In calculating the facilitation effect, the participants mean reaction time in the subject-verb neutral condition was used as the minuend.

To answer the three research questions posed in Experiment 1, three sets of mixed model ANOVAs were calculated. In each set the first ANOVA was calculated across the untransformed reaction time means for all the participants. To control for the possible effects of outliers, the data were then transformed into a base-e logarithm and all analyses were recalculated with the transformed scores. The results from analyses using the transformed data are only reported when they differ from the first set of results. In addition, whenever Mauchly's test of sphericity indicated that sphericity could not be assumed, the Greenhouse-Geisser correction was used. To avoid confusion, the standard degrees of freedom are reported rather than the adjusted degrees of freedom associated with the Greenhouse-Geisser test.

Table 3-2

*Experiment 1: The Mean, Standard Deviation, Maximum and Minimum Word Naming Speeds (in milliseconds) and the Amount of Facilitation by Context Condition*

| | RD Group (*n* = 23) | | | | ND Group (*n* = 31) | | | |
|---|---|---|---|---|---|---|---|---|
| Condition | Mean (*SD*) | Min. | Max. | Facil. | Mean (*SD*) | Min. | Max. | Facil. |
| C | 779<br>(142) | 540 | 1076 | 28 | 691<br>(141) | 366 | 1002 | 43 |
| IC | 897<br>(196) | 586 | 1298 | -90 | 749<br>(41) | 516 | 1028 | -15 |
| SVD | 791<br>(161) | 549 | 1115 | 16 | 723<br>(137) | 520 | 1053 | 11 |
| SVN | 807<br>(170) | 560 | 1189 | ---- | 734<br>(133) | 539 | 1031 | ---- |
| SVP | 796<br>(159) | 567 | 1081 | 11 | 704<br>(158) | 211 | 1019 | 30 |

*Note*. RD = participants with a history of reading difficulties; ND = participants with no history of reading difficulties; C = congruent; IC = incongruent; SVD = subject-verb disrupted; SVN = subject-verb neutral; SVP = subject-verb preserved. Facilitation (Facil.) is the mean naming speed minus the mean naming for the subject-verb neutral context condition.

Next, to control for the possibility that observed differences result simply from differences in reading speed rather than dyslexia, the participants were matched first on their SVN target word naming speed and then on their SVN sentence reading speed. Matching the participants on their SVN naming speed attempts to address the fact that the weaker decoding skills of individuals with developmental dyslexia may require them to spend more effort decoding the individual words in a sentence (Lefly & Pennington, 1991; Gallagher et al., 1996). If weaker decoding skills take resources away from comprehension, they can lead to reduced ability to build an integrated representation of the context sentence. The SVN condition was used as a base condition because the noun and verb of the sentence have a neutral association with the target word and are not expected to facilitate or inhibit the processing of it. The matching resulted in 20 participants in each group. Table 3-3 displays the matched participants' mean, standard deviation, minimum and maximum naming speeds, and facilitation for each condition.

Differences in sentence reading speed, however, can influence the results to the different direction. That is, when an individual reads at a slower rate it may allow for a better use of context because the semantic networks have more time to spread the activation to all the words associated with the target word (Duffy et al., 1989). To control for this possibility, the participants were matched on their SVN mean sentence reading speed. This matching also resulted in 20 participants in each group. The SVN target word naming speed and the SVN sentence reading speed matching resulted in largely overlapping groups with 18 of the 20 RD participants and 16 of the 20 ND participants being present in both matched conditions.

Table 3-3

*Experiment 1: The Mean, Standard Deviation, Maximum, Minimum Word Naming Speeds (in milliseconds) and the Amount of Facilitation by Context Condition using Participants Matched on the Subject-verb Neutral Mean Naming Speed*

| | RD Group (*n* = 20) | | | | ND Group (*n* = 20) | | | |
|---|---|---|---|---|---|---|---|---|
| Condition | Mean (*SD*) | Min. | Max. | Facil. | Mean (*SD*) | Min. | Max. | Facil. |
| C | 747<br>(116) | 540 | 941 | 12 | 721<br>(100) | 541 | 868 | 36 |
| IC | 854<br>(165) | 586 | 1182 | -95 | 779<br>(119) | 567 | 1012 | -21 |
| SVD | 757<br>(135) | 549 | 1072 | 2 | 742<br>(118) | 520 | 1013 | 15 |
| SVN | 759<br>(119) | 559 | 997 | ---- | 758<br>(110) | 592 | 983 | ---- |
| SVP | 754<br>(123) | 567 | 983 | 5 | 735<br>(119) | 515 | 1019 | 23 |

*Note*. RD = participants with a history of reading difficulties; ND = participants with no history of reading difficulties; C = congruent; IC = incongruent; SVD = subject-verb disrupted; SVN = subject-verb neutral; SVP = subject-verb preserved. Facilitation (Facil.) is the mean naming speed minus the mean naming for the subject-verb neutral context condition.

Table 3-4 displays the sentence reading speed matched participants' means, standard deviations, minimum and maximum naming speeds, and facilitation for each condition.

Table 3-4

*Experiment 1: The Mean, Standard Deviation, Maximum, Minimum Word Naming Speeds (in milliseconds) and the Amount of Facilitation by Context Condition Using Participants Matched on the Subject-verb Neutral Mean Sentence Reading Speed*

| | RD Group (*n* = 20) | | | | ND Group (*n* = 20) | | | |
|---|---|---|---|---|---|---|---|---|
| Condition | Mean (*SD*) | Min. | Max. | Facil. | Mean (*SD*) | Min. | Max. | Facil. |
| C | 782<br>(150) | 540 | 1076 | 22 | 714<br>(119) | 541 | 1002 | 32 |
| IC | 903<br>(206) | 586 | 1298 | -100 | 757<br>(128) | 567 | 102 | -12 |
| SVD | 801<br>(163) | 592 | 1115 | 3 | 713<br>(109) | 520 | 959 | 32 |
| SVN | 804<br>(166) | 559 | 1189 | ---- | 746<br>(130) | 548 | 1031 | ---- |
| SVP | 790<br>(152) | 567 | 1077 | 13 | 719<br>(125) | 515 | 1019 | 27 |

*Note*. RD = participants with a history of reading difficulties; ND = participants with no history of reading difficulties; C = congruent; IC = incongruent; SVD = subject-verb disrupted; SVN = subject-verb neutral; SVP = subject-verb preserved. Facilitation (Facil.) is the mean naming speed minus the mean naming for the subject-verb neutral context condition.

The first question to be addressed by this experiment was whether the facilitation effect generated by a congruent context was the same for both groups. A comparison of the SVN condition with the Congruent (C) condition was used as an indication of facilitation. The SVN condition is used as a baseline because the SVN sentences were created by replacing the content words of the congruent sentence with neutral words and by matching the SVN condition to the other conditions in terms of syntax, number of words and identity of words (except for the subject and/or verb).

Repeated measures ANOVA with all the RD participants indicated that the RD participants' performance in C condition was not significantly different, *F* (1, 22) = 1.53, *p* = .229, $MS_e$ = 12352.27, from their performance in SVN condition (difference of 29 ms). Similar analysis with the ND participants showed that the difference of 42 ms was significant, *F* (1, 30) = 13.85, *p* = .001, $MS_e$ = 3816.43.

A mixed model ANOVA with SVN and C conditions (2) as the within-subject factor and the group (2) as the between-subject factor was calculated next. The main effect of group was significant, *F* (1, 52) = 4.48, *p* = .039, $MS_e$ = 19371.31, as was the main effect of condition, *F* (1, 52) = 8.70, *p* = .005, $MS_e$ = 3713.87. The condition by group interaction, however, was not significant, *F* (1, 52) = .28, *p* = .597, $MS_e$ = 3713.87. When the RD participants were matched with the ND participants based on their SVN mean naming speed, the main effect of group, *F* (1, 38) = .16, *p* = .691, $MS_e$ = 10652.39, and the condition by group interaction, *F* (1, 38) = .84, *p* = .365, $MS_e$ = 7053.95, were not significant. The main effect of condition, *F* (1, 38) = 3.30, *p* = .077, $MS_e$ = 7053.95, approached significance. Finally, when the RD and ND participants were matched on their SVN mean sentence reading speed, the main effect of group, *F* (1, 38) = 2.14, *p* = .152, $MS_e$ = 18531.85, and the condition by group interaction, *F* (1, 38) = .14, *p* = .712, $MS_e$ = 7093.82, were not significant, and the main effect of condition again approached significant, *F* (1, 38) = 4.03, *p* = .052, $MS_e$ = 7093.82.

In sum, the ND group experienced significant facilitation, while the RD group did not. Group by condition interaction, however, was not significant in any of the comparisons indicating no significant differences in how the congruent context affected the performance of high-functioning dyslexics and normal adult readers.

The second question addressed by Experiment 1 was whether the effect of inhibition was the same for both groups. To examine this, the SVN condition was compared with the incongruent (IC) condition. Repeated measures ANOVAs with only the RD participants or the ND participants indicated that the 89 ms difference between the conditions shown by the RD group was significant, $F\ (1, 22) = 13.59$, $p = .001$, $MS_e =$ 13461.62, whereas the 16 ms difference shown by the ND group was not, $F\ (1, 30) =$ 2.31, $p = .139$, $MS_e = 3631.44$.

A mixed model ANOVA with SVN and the IC conditions (2) as the within-subject factor and the group (2) as the between-subject factor showed significant main effects of group, $F\ (1, 52) = 7.04$, $p = .011$, $MS_e = 23136.59$, and condition, $F\ (1, 52) =$ 8.92, $p = .000$, $MS_e = 3895.18$. The condition by group interaction, $F\ (1, 52) = 8.96$, $p =$ .004, $MS_e = 3895.18$, was now also significant. When the RD participants were matched with the ND participants based on their SVN mean naming speed or on their SVN mean sentence reading speed, the results remained essentially the same.

In sum, incongruent context inhibited the RD group's performance significantly whereas the same was not true for the ND group. The significant difference in inhibition effect remained even after the groups were matched in target word naming speed or in sentence reading speed.

Finally, to examine whether the groups react differently to the manipulation of syntactic structure, a mixed-model ANOVA with SVN, subject-verb disrupted (SVD) and subject-verb preserved (SVP) conditions (3) as the within-subject factor and the group (2) as the between-subject factor was calculated. The main effect of group approached significant, *F* (1, 52) = 3.99, *p* = .051, $MS_e$ = 20185.22. The main effect of condition, *F* (1, 52) = 1.27, *p* = .284, $MS_e$ = 4424.65, and the condition by group interaction, *F* (1, 52) = .48, *p* = .623, $MS_e$ = 4424.65, were not significant. The results did not vary when the participants were matched on their SVN mean naming speed or on their SVN mean sentence reading speed.

Repeated measures ANOVAs with only the RD participants indicated that the main effect of condition was not significant, *F* (2, 44) = .29, *p* = .672, $MS_e$ = 8395.05. Tests of within-subject contrasts indicated that when compared to the SVN condition, neither the SVD (17 ms) nor the SVP (12 ms) significantly facilitated the RD group's performance. In addition, there was no significant difference between the SVD and the SVP conditions. Similar analysis with the ND participants indicated that the main effect of condition, *F* (2, 60) = 2.01, *p* = .142, $MS_e$ = 3399.38, was not significant. When compared to the SVN condition, neither the SVD (9 ms) nor the SVP (29 ms) condition significantly facilitated the ND group's performance. There was also no significant difference between the SVD and SVP conditions.

In sum, the groups did not react differently to the manipulation of syntactic structure. These results remained even after the groups were matched in target word naming speed or sentence reading speed.

# Discussion

Experiment 1 examined how a sentence prime affects the lexical access process of high-functioning adult dyslexics and normally reading adult university students. Three research questions were posed. The first question asked whether the facilitation effect generated by a congruent context was different for the two groups. As indicated in Tables 3-2, 3-3, and 3-4, both groups experienced facilitation, with the within group analyses indicating that the facilitation effect was significant only for the ND group, the between group comparisons indicated that the facilitation effect was not significantly different for the two groups. Matching the participants on their mean subject-verb neutral target naming speed and their subject-verb neutral mean sentence reading speed did not change the results. The finding suggests that the RD group's decoding speed and sentence reading speed did not affect the differences in the facilitation effect.

In contrast, the analyses of the inhibition effect generated by an incongruent context showed clear differences between the groups. Further examination of the means revealed that the ND participants did not display a significant inhibition effect while the RD participants did. The fact that the ND participants did not display a significant difference between the incongruent and subject-verb neutral conditions suggests that the facilitation effect observed for the ND participants resulted from the use of lexical-lexical priming and can be explained by a modular model of language processing. Lack of inhibition effect suggests that the participants did not attempt to integrate the target word with the incongruent sentence prime prior to naming it. Instead, they likely first accessed the target word directly from the lexicon and only after that attempted to integrate the word with the sentence prime.

The RD participants, on the other hand, displayed a significant inhibition effect and a non-significant facilitation effect. The fact the RD participants displayed a significant inhibition effect suggests that they had difficulty integrating the target word with the incongruent sentence prime. This finding corresponds to the use of an interactive model of language processing because the visual representation of the target word is interacting bi-directionally with context to activate the correct meaning of the word. Duffy et al. (1989) also found an inhibition effect with normally reading university students, which they attributed to the inadequacy of the warning signal that occurred before the appearance of the target word; when the presentation of the warning signal was controlled, the inhibition effect was eliminated. They suggested that the inhibition effect was attributable to the participants processing the target word while still processing the sentence prime. Since participants in the current study controlled the presentation of the target words it is unlikely that the inhibition effect may be attributable to the RD participants processing the target word while still processing the sentence prime. A more likely explanation is that the integrated representation of the sentence prime affected the speed of lexical access.

If the modular model of language processing explains the performance of the ND participants and the interactive model the performance of the RD participants, the two groups should have reacted differently to the manipulations of the syntactic structure of the sentence primes. However, when the subject-verb neutral condition was compared with the subject-verb disrupted and the subject-verb preserved context conditions the groups were not affected differently. Group by condition interaction was not significant and neither group showed facilitation in either SVD or SVP conditions. This is opposite to Duffy et al. (1989), who reported a significant facilitation effect for both the subject-verb disrupted and the subject-verb preserved conditions and no significant differences between the two conditions. Lack of facilitation effects in the current experiment suggests that the SVN condition was not an appropriate control condition because it had a considerably simpler sentence structure than SVP and SVD conditions. If the sentence structure of the SVN condition matched the sentence complexity of the SVD and the SVP conditions, the SVD and SVP may have facilitated the performance. It is also possible that the lack of facilitation was due the very low frequency target words. The participants' understanding of the target words was not assessed and it is likely that facilitation occurs only when the target words are at an adequate level of understanding. To rule out this possibility, the current results need to be replicated with simpler target words. Therefore, the fact that no facilitation was observed may be an artefact of the experimental task and not a real result.

An alternative explanation for the occurrence of inhibition without the presence of a facilitation effect may be that the weak decoding skills of the RD participants have resulted in the establishment of a naming speed ceiling effect. That is, the maximum naming speed achievable to the RD participants is at least partly defined by the deficient lower level processing skills and no amount of contextual facilitation can increase it significantly. Such a ceiling effect would limit facilitation, while still enabling inhibition to occur.

Overall, the RD participants' significant inhibition effect suggests use of an interactive model of language processing. The fact that the inhibition by group interaction remained significant when the participants were matched on word naming speed or on sentence reading speed suggests that interactive language processing is a characteristic of HPDD rather than a result of slow decoding or text reading speed.

# CHAPTER 4:

# EXPERIMENT 2

Experiment 2 examines if HPDDs differ from normal adult readers' in the use of of context to facilitate word recognition. By using sentence primes that biased either the dominant meaning or the subordinate meaning of the sentence-final ambiguous word (a homograph), and target words that had either (a) a strong (high salience), (b) a weak (low salience), or (c) no semantic relationship with the biased meaning of the homograph, Experiment 2 aimed to answer the following questions:

1. Is the initial meaning activation of the homograph sensitive to the prior context in the same manner for the two groups?
2. Is the scope of the meaning activation the same for the two groups?

Homograph meaning frequency refers to the relative frequency in which participants provide semantic associations to each of the possible meanings of a homograph. The dominant meaning of the homograph is the one that receives the most responses; whereas subordinate meanings would receive fewer responses (some homographs may naturally have two equally frequent meanings). By using homographs that had both a dominant and a subordinate meaning, and sentences that strongly biased one of the two meanings, Experiment 2 examined whether HPDDs and normally reading university students differed in how sensitive the initial meaning activation of the homograph is to the prior context. Most models of language processing suggest that without context, only the dominant meaning of the homograph is activated (e.g., Simpson, 1981), or that the dominant meaning is activated more than the subordinate meaning(s) (e.g., Twilley & Dixon, 2000; Dixon & Twilley, 1999). The exceptions are those exhaustive access models (e.g., Lucas, 1987) that argue that all meanings are always (regardless of meaning frequency or context) activated to the same degree.

Similarly, interactive and modular models do not necessarily differ in their predictions about the effect of context and meaning frequency. Interactive models of language processing predict that when preceded by a strongly biasing sentence, homograph meaning activation is contextually sensitive (e.g., Duffy, Kambe & Rayner, 2001; Kellas et al., 1991; Simpson, 1981). Strong forms of these models would predict no meaning frequency effects in the current experiment as the context is expected to activate only the appropriate meaning regardless of its meaning frequency. Other models, such as the reordered access model (Duffy et al., 2001), argue that both meaning frequency and context affect access to the meaning of a homograph. Thus, when the context biases the subordinate meaning, both dominant and subordinate meanings can be simultaneously activated and competition (and slower response times) will be observed. Note, however, that this model is not modular as initial access is not immune to the effects of context; however, it is also not dominated by the context. Most modular models would lead to the same prediction. For example, in the ordered access models (e.g., Hogaboam & Perfetti, 1975) possible meanings of a homograph are accessed one at a time, in the order of their meaning frequency, until a meaning is found that is consistent with the context. As a result, this model would lead to a very fast resolution in the high meaning frequency condition with minimal activation of the less frequent meanings of the homograph (they did not have to be considered), and to a slower resolution in the subordinate condition with residual activation (or inhibition) left on the high frequency meanings that had to be considered and rejected first.

Target salience in Experiment 2 is defined as the strength of the semantic relationship between the target word that is named and the biased meaning of the homograph that precedes it. High-salient targets are those that given the sentence prime (ending with the homograph) are likely to be activated early, whereas low-salient targets are less likely to be activated but still congruent with the sentence prime. Unrelated targets, in contrast, are not likely to be activated at all given the context. Target salience effect then relates to the scope of activation within a word sense during initial processing; if the activation is limited, high-salient targets should be processed faster than low-salient targets. In contrast, if the activation is extensive, then both high- and low-salient targets should be processed faster than unrelated targets.

Paul et al. (1992) suggested that limited activation (only high-salient targets activated) may be enough for immediate comprehension because high-salient targets represent those semantic features that overlap to a high degree with the context. Low-salient targets overlap less with the context, are not central to immediate comprehension, and processing them requires more working memory capacity. However, Paul et al. suggested further that activating low salience information may facilitate later discourse processing as the context may shift. Gernsbacher and Faust (1991), in contrast, suggested that suppression of unnecessary information is important for the comprehension of the context, and that less-skilled comprehenders suffer from less-efficient suppression (see also, Gunter, Wagner, & Friederici, 2003).

Using materials similar to the current experiment, Paul et al. (1992) found context-dependent activation for both high-salient and low-salient targets with university students. Their results suggest that a broad range of information was made available to the language processor. Similarly, Hopkins et al. (1995) showed that both older and younger adults activated both high- and low-salient targets. These results suggest that normally reading adults have sufficient working memory resources for processing of a wide scope of information. However, this may not be true for HPDDs whose working memory and attention resources may be taxed by less automatic lower level processes.

In terms of the target salience effect, modular and interactive models of language processing lead to somewhat different predictions. Specifically, if the language processing is modular, the high-salient target words should be recognized faster than the low-salient targets because of the stronger lexical-lexical priming from the biased homograph meaning to the high-salient target words than to the low-salient target words. Low-salient target words may also be recognized faster than the unrelated words if their semantic relationship with the homograph is strong enough to elicit priming. On the other hand, interactive models predict that a target saliency effect should occur because the contextually appropriate high-salient targets share more semantic features with the context than do the low-salient targets. As a result, the latter may also be inhibited relatively early in the processing. If this is true, it would lead to the prediction that high-salient targets are recognized faster than the unrelated targets whereas low-salient targets may be recognized slower than the unrelated targets due to inhibition.

Finally, we should note that Kellas et al. (1991) reported a significant meaning frequency by target salience interaction with normally reading university students. Specifically, their results indicate that sentences biasing high meaning frequency of the sentence-final homograph facilitated responses only to high-salient targets, whereas sentences biasing the subordinate meanings of the homographs resulted in facilitation for both high- and low-salient targets.

## Method

### *Participants*

The experimental group (RD) and the control group (ND) participants were the same as in Experiment 1.

### *Tasks*

#### *No-Context Word Naming Speed*

To determine each participants word naming speed when no context is provided, 30 regular words from Castles and Coltheart (1996) were presented to the participants using DirectRT research software. The mean length of the words was 5.2 letters, with a mean Kucera-Francis word frequency of 62.93 and a mean bigram frequency of 1723.57 (see Appendix D for details). Words were presented in random order in black capital letters against a white background in the centre of the screen. The participants were asked to name the word as quickly and accurately as possible. The word remained on the screen until the participant responded and the software recorded the onset of voice response. The experimenter then recorded, by pressing one of two number pad keys whether the participant responded correctly or not. Once the experimenter pressed the appropriate key, the next word appeared on the screen. For all conditions the participants were seated approximately 50 cm from a colour monitor with targets subtended at a visual angle of approximately 12.75° horizontally and 1.82° vertically.

*Word Naming in Context*

To examine the effect homograph meaning frequency and target salience have on word naming and the extent to which meanings are activated during sentence processing, 60 sentence primes and 60 target words from Hopkins et al. (1995) were used. Each sentence prime was a simple declarative sentence that was three to eight words in length. In addition, each sentence was constructed so that it ended in a homograph, it did not include any words related to the homograph (i.e., there was no possibility of lexical-lexical priming of the homograph), and it did not make the homograph predictable. For each homograph two sentences were constructed: one biasing the dominant meaning of the homograph and one biasing the subordinate meaning. The targets used for the word naming either had (a) a high salience (strong semantic relationship), (b) a low salience (weak semantic relationship), or (c) no semantic relationship with the biased meaning of the sentence ending homograph.

Overall, there were six context conditions:

1. The dominant-high (DH) condition consisted of ten sentence primes that biased the dominant meaning of the homograph that ended each sentence and was followed by a high-salient target word that had a strong semantic relationship to the dominant meaning of the homograph.
2. The dominant-low (DL) condition consisted of ten sentence primes that biased the dominant meaning of the homograph that ended each sentence and was followed by a low-salient target word that had a weak semantic relationship to the dominant meaning of the homograph.

3. The dominant-unrelated (DUR) condition consisted of ten sentence primes that biased the dominant meaning of the homograph that ended each sentence. The target word that followed each sentence prime was unrelated to the homograph.
4. The subdominant-high (SH) condition consisted of ten sentence primes that biased the subdominant (low frequency) meaning of the homograph that ended each sentence. Each sentence prime was then followed by a high-salient target word that had a strong semantic relationship to the subdominant meaning of the homograph.
5. The subdominant-low (SL) condition consisted of ten sentence primes that biased the subdominant meaning of the homograph that ended each sentence, and was followed by a low-salient target word that had a weak semantic relationship to the subdominant meaning of the homograph.
6. The subdominant-unrelated (SUR) condition consisted of ten sentence primes that biased the subdominant meaning of the homograph that ended each sentence. The target word that followed each sentence prime was unrelated to the homograph.

For each condition the targets were matched in terms of frequency of occurrence in the English Language (Kucera-Francis frequency), bigram frequency, number of letters, and number of syllables. Appendix E displays the descriptive measures for each target word used in the context conditions. Across the conditions, there were no significant differences in the frequency of occurrence, bigram frequency, or number of syllables in target words. However, as indicated in Appendix E, the subdominant-low condition ($M = 7.10$, $SD = 2.56$) had significantly more letters in its target words than the other conditions, $F(4, 55) = 5.61$, $p = .001$.

Each sentence was presented in random order and appeared individually on the screen. The sentences were presented in black letters against a white background. First the participant silently read the sentence and pressed the "enter" key when he/she had finished reading the sentence. The sentence was then removed from the screen and the target word, in capital letters, appeared immediately in the centre of the screen. The participant named the target word as quickly and accurately as possible. The target word remained on the screen until the participant responded and DirectRT recorded the onset of the voice response. Once the participant responded, the experimenter recorded, by pressing one of two number pad keys, whether the participant responded correctly or not and the next sentence appeared on the screen.

## Results

To obtain comparable naming latencies across conditions, all reaction times that corresponded to inaccurate responses were first removed. Specifically, the RD participants made a total of 2 errors in the Subordinate-Low condition, 2 errors in the Unrelated condition, and 13 errors in the No-Context condition. The ND participants made 5 errors in the No-Context condition. Overall, inaccurate responses constituted .065% of the data. In addition, machine errors (deemed as naming latencies below 200 ms or above 5000 ms) were removed before the data were analyzed. Overall, the machine errors constituted 9.73% of the naming speed data.

The analyses reported below were calculated first with all the remaining naming latencies included. To control for the possible effects of outliers, the data were then transformed into a base-e logarithm and all analyses were recalculated with the transformed scores. The results from analyses using the transformed data are reported only when they differ from the first set of results. Furthermore, initial analyses indicated that the RD group (*M* = 867.32, *SD* = 201.62) had a significantly, *F* (1, 54) = 10.10, *p* < .002, slower no-context word naming speed than the ND group (*M* = 735.04, *SD* = 113.54). To control for the possible effects of differences in naming speed, the participants were first matched on their no-context word naming speed. The matching resulted in 20 participants in each group. Matching the participants on their no-context naming speed allowed for the examination of whether weak phonological sensitivity skills and the resultant poorer decoding skills explain the possible differences between the groups' performances.

Second, sentence reading speed analyses indicated that the RD group (*M* = 1418.30, *SD* = 471.72) read the priming sentences slower than the ND group (*M* = 996.72, *SD* = 278.59), which had significance, *F* (1, 54) = 17.32, *p* < .001. Similar to Experiment 1, a subgroup of participants were matched on their mean sentence reading speed to control for the possible effects of slower reading rate. This matching also resulted in 20 participants in each group. The two matching procedures resulted in largely overlapping groups with 18 of the 20 RD participants and 12 of the 20 ND participants being present in both the No-Context naming speed match and in the sentence reading speed match.

In addition, whenever Mauchly's test of sphericity indicated that sphericity could not be assumed, the Greenhouse-Geisser correction was used. To avoid confusion, the standard degrees of freedom are reported rather than the adjusted degrees of freedom associated with the Greenhouse-Geisser test.

Table 4-1 shows the mean (standard deviations in parenthesis), minimum, and maximum naming latencies for each condition for the full sample. Table 4-1 indicates that the RD group was slower than the ND group in all conditions.

Table 4-1

*Experiment 2: The mean, standard deviation, maximum and minimum word naming speeds (in milliseconds) of each context condition for the entire data set.*

| | RD Group (*n* = 24) | | | ND Group (*n* = 31) | | |
|---|---|---|---|---|---|---|
| Condition | Mean (*SD*) | Min. | Max. | Mean (*SD*) | Min. | Max. |
| DH | 710<br>(148) | 519 | 1097 | 655<br>(113) | 449 | 908 |
| DL | 799<br>(155) | 532 | 1105 | 680<br>(142) | 306 | 941 |
| SH | 757<br>(152) | 537 | 1150 | 694<br>(116) | 531 | 1015 |
| SL | 797<br>(163) | 544 | 1161 | 684<br>(114) | 511 | 919 |
| DUR | 717<br>(172) | 463 | 1114 | 661<br>(153) | 292 | 961 |
| SUR | 789<br>(209) | 375 | 1312 | 647<br>(151) | 265 | 940 |

*Note*. DH = Dominant-High; DL = Dominant-Low; SH = Subordinate-High; SL = Subordinate-Low; DUR = Dominant-Unrelated; SUR = Subordinate-unrelated.

To examine whether the effects of (a) homograph meaning frequency and (b) target salience on target naming speed are the same for the RD group and the ND group, four different mixed model ANOVAs with target salience (3; high, low, and unrelated) and homograph meaning frequency (2; dominate and subordinate) as the within-subject factors and the Group (2) as the between-subject factor were calculated. The first included all the participants and used the raw scores as the dependent variable. This was followed by similar analyses with the log-transformed scores for all participants, and with raw scores for the no-context word naming speed matched and sentence reading speed matched sub-samples of participants. The results from these analyses are reported below separately for meaning frequency, target salience, and meaning frequency by target salience interaction. The main effect of group was significant in the first three analysis ($ps < .017$), but not when the groups were matched on the no-context word naming speed or on the sentence reading speed ($ps > .106$).

*Target Salience.* A mixed model ANOVA with all the participants and raw scores as the dependent variable showed a significant main effect of Target Salience, $F\ (2, 106) = 8.90$, $p < .001$, $MS_e = 5378.79$, as well as a significant target Salience by Group interaction, $F\ (2, 106) = 4.41$, $p = .014$, $MS_e = 5378.79$. When the data were transformed into a base-e logarithm, the main effect of Target Salience remained significant but the Target Salience by Group interaction now approached significance, $F\ (2,106) = 3.02$, $p = .053$, $MS_e = .015$. The same was true for the analyses with no-context naming speed matched sub-sample. Finally, when the RD participants were matched with the ND participants based on their mean sentence reading speed, the main effect of Target Salience, $F\ (2, 76) = 6.39$, $p = .003$, $MS_e = 37978.43$, remained significant, but the Target Salience by Group interaction, $F\ (2, 76) = 2.07$, $p = .133$, $MS_e = 5632.13$, was no longer significant, indicating that the target salience differences may result from sentence reading speed differences.

Figure 4-1a to Figure 41-c display the estimated marginal means for the three target salience conditions separately for the RD and ND groups. Figure 4-1a includes the entire sample, Figure 4-1b includes only the no-context naming speed matched participants, and Figure 4-1c includes only the sentence reading speed matched participants.

Tests of within-subject contrasts with the full data indicated that the low-salient condition was significantly slower than high-salient, $F\ (1, 53) = 13.20, p = .001, MS_e =$ 5412.02, and unrelated, $F\ (1, 53) = 11.93, p = .001, MS_e = 6048.94$, conditions whereas the difference between the latter two was not significant, $F\ (1, 53) = .000, p = .984, MS_e = 4675.41$. These differences remained significant with log-transformed scores, and with the two matched samples (Figures 4-1b and 4-1c).

Post hoc analyses of Target Salience by Group interactions with the full data indicated that there was a significant difference between the RD and the ND participants' responses to the high-salient condition vs. the unrelated condition, $F\ (1, 53) = 4.70, p = .035, MS_e = 4675.41$, and between their responses to the high-salient vs. low-salient conditions, $F\ (1, 53) = 8.34, p = .006, MS_e = 5412.02$. There were no significant differences between the groups' responses to the low-salient condition vs. the unrelated condition, $F\ (1, 53) = .682, p = .413, MS_e = 6048.94$.

The first of these interactions resulted from the fact that the RD participants responded faster to the high-salient condition than to the unrelated condition whereas the opposite was true for the ND participants; however, neither the 17.60 ms facilitation

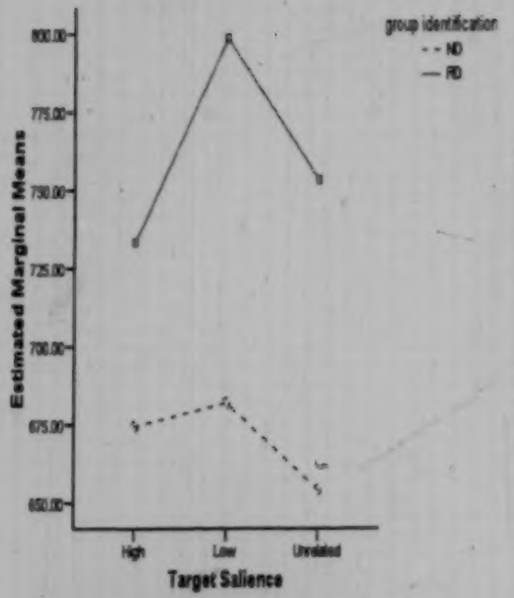

*Figure 4-1a.* The marginal estimated means of Target Salience by Group including the entire data set.

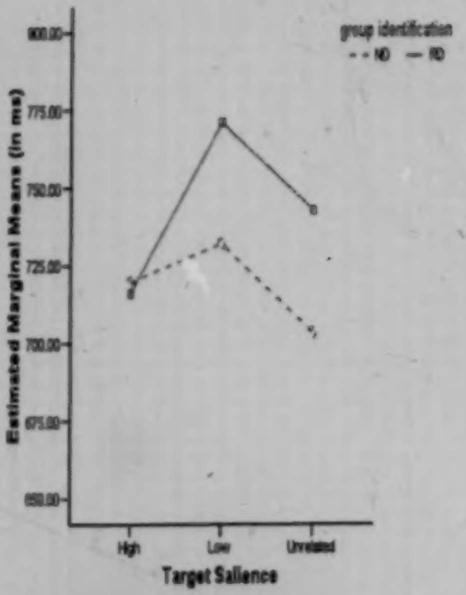

*Figure 4-1b.* The marginal estimated means of Target Salience by Group including only the no-context naming speed matched participants.

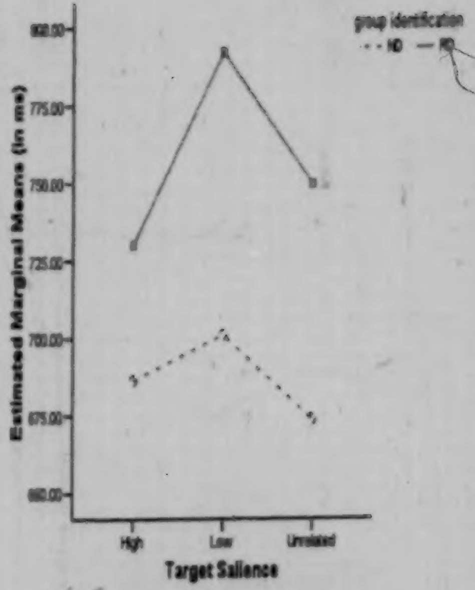

*Figure 4-1c.* The marginal estimated means of Target Salience by Group including the sentence reading speed matched participants.

effect for the RD group or the 17.33 ms inhibition effect for the ND group were significant (both *p*s > .10). When compared to low-salient targets, RD participants responded significantly faster (65.21 ms, $p = .002$) to the high-salient targets whereas the difference between the two conditions was not significant for the ND participants (7.46 ms). Finally, the comparison of the low-salient targets with the unrelated targets revealed that the low-salient targets were responded to slower by both the RD participants' (45.25 ms.) and the ND participants' (28.79 ms); both differences were significant.

When the data were transformed into a base-e logarithm, the difference between the RD and ND participants' responses to the high-salient vs. unrelated conditions, $F\,(1, 53) = 2.99$, $p = .090$, $MS_e = .017$, approached significance. The other two comparisons remained the same as with the raw scores. When the participants were matched on their No-Context naming speed, there was no longer a significant difference between the RD and ND participants' responses to the high-salient vs. unrelated condition and the high-salient vs. low-salient interaction approached significance ($p = .050$). Finally, when the participants were matched on their mean sentence reading speed, there was also no longer a significant difference between the RD and ND participants' responses to the high-salient vs. unrelated conditions, or to the high-salient vs. low-salient conditions.

In sum, these analyses showed a robust main effect of target salience that can be mainly attributed to the performance of the RD group, although the group by target salience interaction was not robust. Compared to the unrelated condition, the RD group's performance was significantly slower in the low-salient condition and insignificantly faster in the high-salient condition. In contrast, the ND group's performance was insignificantly slower in the high-salient condition and significantly slower in the low-salient conditions when compared to the unrelated condition. When the groups were matched on their sentence reading speed, all the differences between them were mostly eliminated.

*Homograph Meaning Frequency.* A mixed model ANOVA with all the participants and raw scores as the dependent variable showed a significant main effect of Meaning Frequency, $F$ (1, 53) = 13.85, $p$ = .000, $MS_e$ = 3495.05, and a significant Meaning Frequency by Group interaction, $F$ (1, 53) = 5.09, $p$ = .028, $MS_e$ = 3495.05. When the ANOVA was repeated with the transformed scores, the main effect of Meaning Frequency remained significant and the Meaning Frequency by Group interaction, $F$ (1, 53) = 3.03, $p$ = .087, $MS_e$ = .005, approached significance.

When the RD participants were matched with the ND participants based on their No-Context naming speed, the main effect of Meaning Frequency, $F$ (1, 38) = 9.58, $p$ = .004, $MS_e$ = 3163.01, and the Meaning Frequency by Group interaction, $F$ (1, 38) = 10.71, $p$ = .002, $MS_e$ = 3163.01, were again both significant. Finally, when the RD participants were matched with the ND participants based on their mean sentence reading speed, the main effect of Meaning Frequency was again significant, $F$ (1, 38) = 13.69, $p$ = .001, $MS_e$ = 3863.80, and the Meaning Frequency by Group interaction, $F$ (1, 38) = 3.08, $p$ = .088, $MS_e$ = 3863.80, approached significance.

Figure 4-2a to Figure 4-2c show the estimated marginal means for the two conditions separately for the RD and ND groups. Both groups responded faster to the dominant condition than to the subordinate condition, with the RD participants responding slower than the ND participants. Significant interaction resulted from the difference between the conditions being 39.22 ms for the RD group and only 9.62 ms for

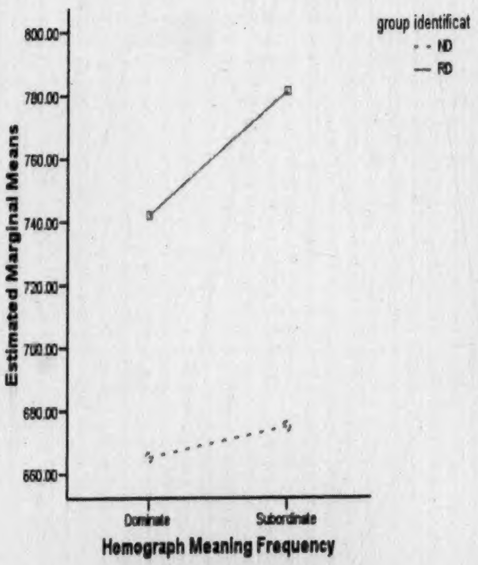

*Figure 4-2a.* The marginal estimated of Homograph Meaning Frequency by Group including the entire data set.

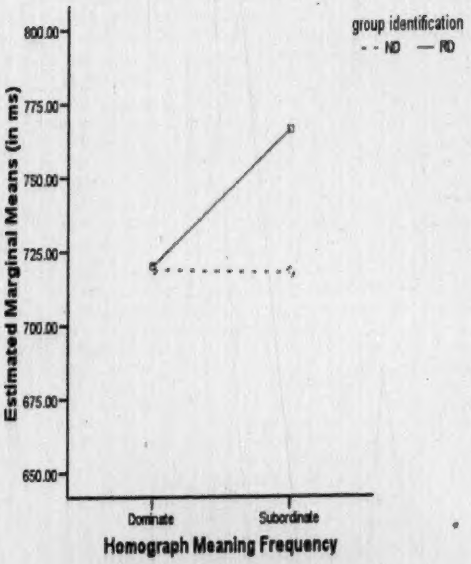

*Figure 4-2b.* The marginal estimated of Homograph Meaning Frequency by Group including the no-context naming speed matched participants.

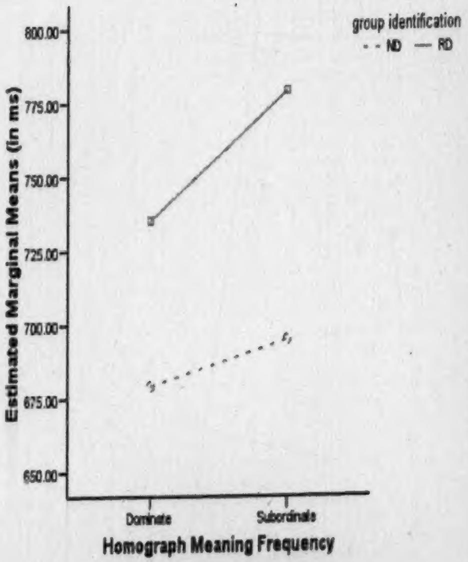

*Figure 4-2c.* The marginal estimated of Homograph Meaning Frequency by Group including the sentence reading speed matched participants.

the ND group. Within-group analyses indicated that the difference between the two conditions was significant for the RD group, $F$ (1, 23) = 10.16, $p$ = .004, $MS_e$ = 3633.22, but not for the ND group, $F$ (1, 30) = 2.15, $p$ = .153, $MS_e$ = 1330.92. When the participants were matched on their No-Context naming speed (Figure 4-2b) and their mean sentence reading speed (Figure 4-2c), the differences between conditions remained very similar.

In sum, these analyses showed a robust homograph meaning frequency effect with the RD group benefiting significantly from the dominate condition when compared to the subordinate condition. In contrast, the ND group's performance was not significantly affected by the meaning frequency.

*Meaning Frequency by Target Salience.* A mixed model ANOVA with the full data showed a significant Meaning Frequency by Target Salience interaction, $F$ (2,106) = 3.72, $p$ = .033, $MS_e$ = 3820.93, as well as a significant three-way interaction between Group, Target Salience, and Meaning Frequency, $F$ (2,106) = 4.96, $p$ = .012, $MS_e$ = 3820.93. When the data were transformed into a base-e logarithm, the Meaning Frequency by Target Salience interaction, $F$ (2,106) = 4.78, $p$ = .064, $MS_e$ = .009, approached significance but the three-way interaction remained significant, $F$ (2, 106) = 4.78, $p$ = .016, $MS_e$ = .009. The three-way interaction remained significant when the groups were matched on no-context naming speed or on mean sentence reading speed.

Figure 4-3a to Figure 4-3c display the effect of target salience separately for the two homograph meaning frequency conditions for RD and ND groups. Figure 4-3a indicates that while both groups responded faster to high-salient targets than to unrelated targets in the dominant condition, the RD group did so also in the subordinate condition

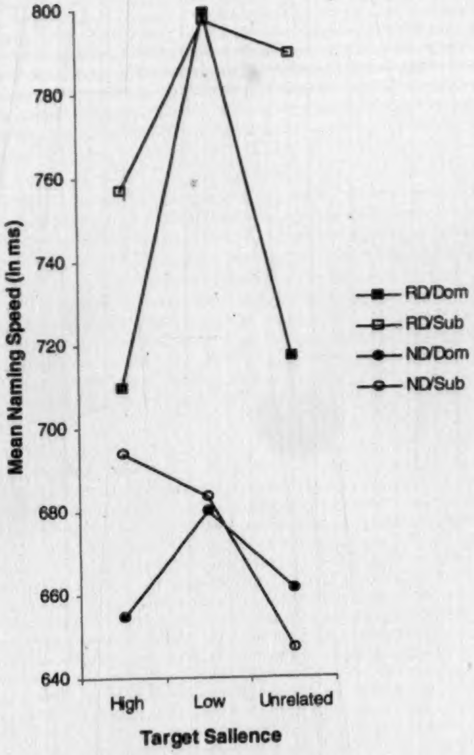

*Figure 4-3a*. The effect of Target Salience by Homograph Meaning Frequency including the entire data set.

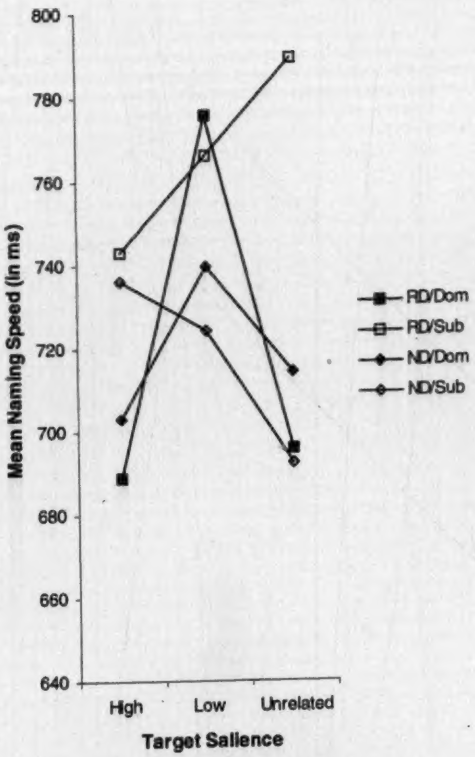

*Figure 4-3b*. The effect of Target Salience by Homograph Meaning Frequency including the no-context naming speed matched participants.

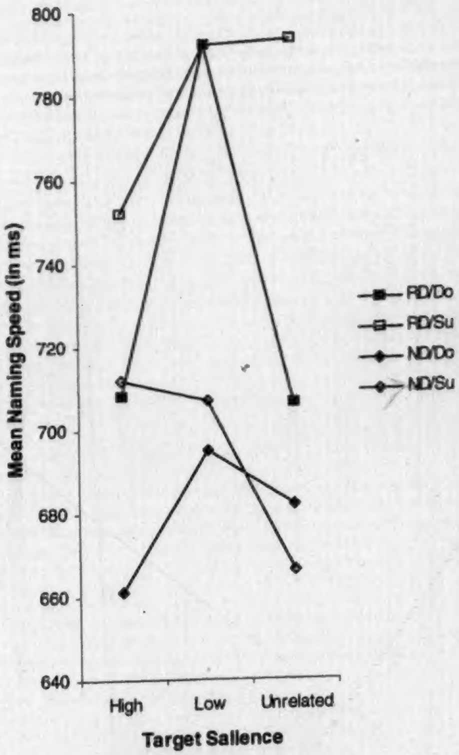

*Figure 4-3c*. The effect of Target Salience by Homograph Meaning Frequency including the sentence reading speed matched participants.

whereas the ND group now showed inhibition. Further, Figure 4-3a indicates that the significant inhibition observed for the low-salient targets is limited to the dominant context condition for the RD group.

Figure 4-3a to Figure 4-3c indicate that meaning frequency has no effect for the naming times of low-salient targets for either group. Post hoc analyses indicated that, the effect of meaning frequency for the ND group was limited to the high-salient targets (dominate 39 ms faster than subordinate, $F$ (1,30) = 11.84, $p = .002$, $MS_e = 4042.63$), whereas for the RD group, both high-salient (dominate 47 ms faster than subordinate, $F$ (1, 23) = 9.97, $p = .004$, $MS_e = 5394.64$) and unrelated (dominate 72 ms faster than subordinate, $F$ (1,23) = 5.45, $p = .029$, $MS_e = 22934.65$) targets showed a context effect. Figures 4-3a and 4-3b show the same data for the matched groups. While the position of the lines changes due to matching, the interpretation of the figures is very similar to Figure 4-3a.

## Discussion

Experiment 2 examined whether HPDDs and normal reading university students differed in (a) the scope of the initial meaning activation of the homograph, and (b) how sensitive the initial meaning activation of the homograph is to the prior context. In response to the first research question, results from Experiment 2 indicate that the scope of meaning activation was not the same for the two groups. Analyses with the full sample showed that the RD participants' naming times in all target salience conditions were slower than the ND participants' naming times. The fact that slower naming times remained even after a subgroup of participants were matched on their no-context naming speed suggests that the RD participants' slower reaction times cannot be attributable to their possibly poorer decoding abilities (Bruck, 1990; Aaron, 1985; Lefly & Pennington, 1991; Gallagher et al., 1996; van der Leij & van Daal, 1999): while matching resulted in equal response times to the high-salient targets, the RD participants still responded slower to the low-salient and unrelated targets. However, the analyses also showed that target salience by group interaction was significant or approached significance when the participants were matched on their no-context naming speed. Only when the two groups were matched on their mean sentence reading speed was the target salience by group interaction not significant. This last result suggests that the overall reading rate rather than RD status may account for the observed target salience effect. This conclusion, however, is qualified by a significant three-way interaction between group, target salience, and meaning frequency that remained even after the groups were matched on no-context naming speed or mean sentence reading speed. Figures 4-3a to 4-3b indicate that the two groups showed roughly similar patterns of target salience effects (high-salient = unrelated < low-salient) in the dominant meaning frequency condition, whereas responses to high-salient targets were clearly different in the subordinate meaning frequency condition: for the RD group, responses to high-salient targets were clearly faster than responses to unrelated or low-salient targets, whereas the opposite was true for the ND participants. These results indicate that the groups clearly differed in how they processed subordinate meaning frequency homographs.

The fact that the RD group experienced facilitation for the high-salient targets in the subordinate condition and inhibition for the low-salient targets in the dominant condition when compared to the unrelated condition suggests (a) context sensitive processing of homographs, and (b) limited scope of meaning activation or quick suppression of less-relevant information. These results are in accordance with various interactive models of language processing. However, taken together with the significant meaning frequency effect, results from Experiment 2 suggest that both meaning frequency of the homograph and the context contributed to the activation of the homograph meanings. Only the reordered access model can accommodate all of these effects.

Similar to the RD group, the ND group responded significantly slower to the low-salient targets compared to the unrelated targets; however, they showed no reliable differences between high-salient and low-salient targets, or between high-salient and unrelated targets. In addition, their performance was not affected by the meaning frequency. Figure 4-3a shows again that these results are partly qualified by interaction between target salience and meaning frequency. Specifically, while low-salient targets were responded slower in both the dominant and the subordinate meaning frequency conditions, high-salient targets were the slowest in the subordinate and the fastest in the dominant meaning frequency conditions. Alternatively, Figure 4-3a indicates that while low-salient and unrelated targets were responded to equally across the two meaning frequency conditions, the same was not true for the high-salient targets. These results suggest first a relatively narrow scope of meaning activation and fail to replicate earlier findings by Paul et al. (1992) and Hopkins et al. (1995). Second, significant inhibition effects observed in particular for both high- and low-salient targets following subordinate primes indicate context effects that are more congruent with interactive models of language processing than with modular models. It should be noted, however, that it is also possible that the ND group's strong automatic word recognition abilities meant that they did not consistently use the context primes. If this was the case, it would support Stanovich and West's (1981, 1983) argument that normal readers do not use an interactive processing model because they do not need to use their attentional capacity for word prediction. Whether context sentences were read carefully was unfortunately not controlled in Experiment 2.

In sum, the results from Experiment 2 suggest that the RD group and the ND group differed in how target salience and homograph meaning frequency affected their word recognition. The reordered access model, one instance of interactive models of language processing, could account for the RD groups' performance in that they seemed to use both meaning frequency and target salience information. The ND group's performance pattern was less clear. Both groups showed a relatively narrow scope of meaning activation. Suppression of less relevant information, as indicated by the inhibition of low-salient targets, may have been particularly strong for the RD participants.

# CHAPTER 5

## EXPERIMENT 3

By using prime words from stories that are (a) imaginative and catchy (high-context saliency; H-CS) and (b) common and simple (low-context saliency; L-CS) and four different conditions of target words (non-primed words from the H-CS story, primed words from the H-CS story, non-primed words from the L-CS story, and primed words from the L-CS story), Experiment 3 aims to answer the following questions:

1. Is the effect of contextual priming on recognition speed and error rate different for the two groups when the primes are only contextually and not semantically related to the targets?
2. Does the high salience context dominate the overall recollection of the words from the stories and inhibit the contextual facilitation effect of the words presented in the low salience story differently for the two groups?

Experiments 1 and 2 examined the effect of context by looking at different mechanisms of semantic priming. In all conditions, the primes and the targets were semantically related. Experiment 3 examines whether simply presenting the two words – the prime and the target – in the same story is enough to create a contextual connection between them when they are otherwise not semantically related. Thus, if we observe priming effect, it is no longer based on semantic relationships but on a looser contextual relationship.

The second question examined in Experiment 3 is the effect of overall contextual salience. Charwarski and Sternberg (1993) suggested that when a person is presented with two types of stories, one that is imaginative and catchy and one that is common and simple, the story that is imaginative and catchy should overpower the recall of the simpler story. During the word recognition task then, the presentation of a prime from the high-salient story should facilitate the recognition of words that came from the same story because not only does the prime assist in the recognition of the word, but there is also residual priming from the salient story (Charwarski & Sternberg, 1993). In contrast, facilitation should not occur or occur to a lesser degree for the primed words from the less salient story because its recall is negatively affected by the more salient story (Charwarski & Sternberg, 1993). Charwarski and Sternberg's study on the effect contextual factors have on word recognition found that even if the relationship between a prime and a target is relatively weak that a priming effect can still be obtained provided that the items are related by the context of their presentation. This finding, however, was only significant in terms of recognition speeds and not error rates. Overall, their findings are contrary to the assertion that priming effects occur exclusively when the primes and targets are closely related (Charwarski & Sternberg, 1993; Paul & Kellas, 2004). Charwarski and Sternberg's study on the effect contextual factors has on word recognition found that context influenced the priming effects of close semantic relations. Charwarski and Sternberg's results have not been replicated and since their participants were university students who did not have a reported history of reading difficulties it needs to be determined if their findings can be generalized to HPDDs.

In addition, Experiment 3 will use a different response mode than experiments 1 and 2. In the previous experiments, contextual inhibition effect was observed for the RD participants whereas facilitation effect was not. A proposed explanation for this occurrence is that the weak decoding skills of the RD participants may have resulted in the establishment of a naming speed ceiling effect. That is, the maximum naming speed achievable to the RD participants is at least partly defined by their deficient lower level processing skills so that contextual facilitation cannot increase it significantly. A naming speed ceiling effect is a plausible explanation particularly if the residual processing deficit is located in output phonology, as suggested by Griffiths and Snowling (2001). The possible occurrence of such a ceiling effect is removed in the current experiment by having the participants merely make a categorical "yes" or "no" decision as to whether a word had appeared in one of the two stories presented, and press a key accordingly. Under these conditions, it is possible that a priming effect may occur.

## Method

### *Participants*

The same participants from experiment one were used.

### *Task*

To examine whether context plays an inhibitory as well as a facilitatory role in word recognition, Charwarski and Sternberg's (1993) task was used. Both groups were first presented with a story (approx. 450 words) from *Reader's Digest* that had a low contextual salience (L-CS) and a story (approx. 450 words) that had a high contextual salience (H-CS) (See Appendix F). The stories were followed by a list of 179 words that were presented in a fixed order (See Appendix G). Specifically, there were 20 non-primed words from the H-CS story (H-CS NPr), 20 primed words from the H-CS story (H-CS Pr), 19 non-primed words from the L-CS story (H-CS NPr), 20 primed words from the L-CS story (L-CS Pr), and 80 words that were not present in either story (UR).

A word was considered primed if the word (the prime) preceding it came from the same story as the target word.

The stories were presented in random order on a computer screen in black letters against a white background. The participant read silently each screen and pressed the "enter" key to bring up the next section of the story. When the second story was presented, the participants were not given any warning that they were reading a new story (e.g., no title); however, the contexts of the stories were significantly different to enable the participants to recognize that they were reading a new story. There were no time restraints for reading the stories.

After reading the last section of the second story, the story was removed from the screen and the target word, in small letters, appeared immediately in the centre of the screen. The participant was asked to indicate, as quickly and accurately as possible, whether the target word came from one of the stories by pressing one of two keypad keys, labelled "yes" and "no." The target remained on the screen until the participant responded. Once the participant pressed the one of the appropriate keys, the next word appeared on the screen. The participants were seated approximately 50 cm from a colour monitor with targets subtended at a visual angle of approximately 12.75° horizontally and 1.82° vertically.

## Results

The error rate data were calculated using two data sets: (a) an inclusive data set that contained responses to all target words, and (b) an exclusive data set that included responses to all non-primed target words but only correctly primed target words. The removed incorrectly primed target words were those primed target words that were preceded by a prime that was incorrectly identified as not coming from the presented stories (NO pressed for the prime when YES should have been pressed). The inclusive data set for the recognition speed analyses included only correct responses to all target words, and the exclusive data set was otherwise similar but the correct responses to incorrectly primed target words were removed from the analyses. Recognition speeds associated with incorrect responses were not analyzed (see Appendix H for detailed description of the excluded data).

To examine whether the effects of (a) saliency and (b) priming on error rates and recognition speeds is the same for the RD group and the ND group, four different mixed model ANOVAs with Saliency (2; high and low) and Priming (2; primed and non-primed) as the within-subject factors and the Group (2) as the between-subject factor were calculated. The first ANOVA used the inclusive data set error rate as the dependent variables, the second used the exclusive data set error rate as the dependent variable, the third used the inclusive data set recognition speed as the dependent variable, and the fourth used the exclusive data set recognition speed as the dependent variable.

To control for the possible effects of outliers, all data were then transformed into a base-e logarithm and the analyses were recalculated. The results obtained using the transformed data are reported only when they differ from the first set of results. In addition, whenever Mauchly's test of sphericity indicated that sphericity could not be assumed, the Greenhouse-Geisser correction was used. To avoid confusion, the standard degrees of freedom are reported rather than the adjusted degrees of freedom associated with the Greenhouse-Geisser test.

### *Error Rate*

Table 5-1 (inclusive data set) and Table 5-2 (exclusive data set) displays in percentages the error rate means, standard deviations, maximums and minimums for each condition.

Table 5-1

*Experiment 3: The Mean, Standard Deviation, Maximum and Minimum Error Rates Displayed in Percentages for Each Context Condition (Inclusive Data Set)*

| | RD Group (*n* = 25) | | | ND Group (*n* = 31) | | |
|---|---|---|---|---|---|---|
| Condition | Mean (*SD*) | Min. | Max. | Mean (*SD*) | Min. | Max. |
| H-CS NP ER | 29.40<br>(15.83) | 5.00 | 70.00 | 24.52<br>(11.21) | 5.00 | 45.00 |
| H-CS P ER | 26.60<br>(14.70) | 10.00 | 60.00 | 21.29<br>(10.16) | .00 | 40.00 |
| L-CS NP ER | 22.11<br>(12.98) | .00 | 52.63 | 22.58<br>(9.14) | 5.26 | 36.84 |
| L-CS P ER | 25.90<br>(16.78) | 4.76 | 66.67 | 23.35<br>(12.62) | .00 | 52.38 |

*Note*. RD = participants with a history of reading difficulties; ND = participants with no history of reading difficulties; H-CS NP E = H-CS non-primed errors; H-CS P E = H-CS primed errors; L-CS NP E = L-CS non-primed errors; L-CS P E = L-CS primed errors.

Tables 5-1 and 5-2 indicate that the RD group made slightly more errors in most conditions. However, a mixed model ANOVA using the inclusive data showed no significant main effect of group, *F* (1, 54) = 1.17, *p* = .284, $MS_e$ = 111.324, on the error rate. When the exclusive data set was used, the results remained unchanged, *F* (1, 54) = 1.41, *p* = .240, $MS_e$ = 108.976. For both data sets the results remained unchanged when the data were transformed into a base-e logarithm.

Table 5-2

*The Mean, Standard Deviation, Maximum and Minimum Error Rates Displayed in Percentages for each Context Condition (Exclusive Data Set)*

| | RD Group (*n* = 25) | | | ND Group (*n* = 31) | | |
|---|---|---|---|---|---|---|
| Condition | Mean (*SD*) | Min. | Max. | Mean (*SD*) | Min. | Max. |
| H-CS NP ER | 29.20<br>(15.32) | 5.00 | 65.00 | 24.52<br>(11.21) | 5.00 | 45.00 |
| H-CS P ER | 25.75<br>(14.44) | 6.67 | 63.64 | 18.34<br>(9.74) | .00 | 43.75 |
| L-CS NP ER | 22.11<br>(12.98) | .00 | 52.63 | 22.58<br>(9.14) | 5.26 | 36.84 |
| L-CS P ER | 23.63<br>(20.20) | .00 | 71.43 | 21.91<br>(11.45) | .00 | 53.85 |

*Note*. RD = participants with a history of reading difficulties; ND = participants with no history of reading difficulties; H-CS NP E = H-CS non-primed errors; H-CS P E = H-CS primed errors; L-CS NP E = L-CS non-primed errors; L-CS P E = L-CS primed errors.

*Priming*. The first question to be addressed by Experiment 3 was whether the effect of contextual priming was different for the two groups when the priming effect was based on contextual-only rather than contextual-semantic relationships between the primes and target words. A mixed model ANOVA with the inclusive data error rate as the dependent variable showed no significant main effect of Priming, $F$ (1, 54) = .09, $p$ = .768, $MS_e$ = 41.99, as well as no significant Priming by Group interaction, $F$ (1, 54) = .49, $p$ = .486, $MS_e$ = 41.99. When the data were transformed into a base-e logarithm, the results remained unchanged. When the exclusive data set was used, the main effect of Priming, $F$ (1, 50) = 1.42, $p$ = .240, $MS_e$ = .278 and the Priming by Group interaction, $F$ (1, 50) = .78, $p$ = .380, $MS_e$ = .278, were again not significant. When the exclusive data set's base-e logarithm transformed scores were used, the results remained unchanged.

In sum, when the priming effect was based on contextual-only rather than contextual-semantic relationships, neither group showed significant priming effects on their error rates.

*Saliency.* The second question to be addressed by Experiment 3 was whether the effect of context saliency was different for the two groups. A mixed model ANOVA with the inclusive data error rate as the dependent variable showed no significant main effect of Saliency, $F$ (1, 54) = 2.74, $p$ = .104, $MS_e$ = 78.29. Saliency by Group interaction, $F$ (1, 54) = 2.91, $p$ = .094, $MS_e$ = 78.29, however, approached significance. When the data were transformed into a base-e logarithm, the results remained unchanged. When the exclusive data set was used, the main effect of Saliency was again not significant, $F$ (1, 54) = 2.30, $p$ = .135, $MS_e$ = 86.23, but the Saliency by Group interaction was, $F$ (1, 54) = 4.73, $p$ = .034, $MS_e$ = 86.23. When the exclusive data set's base-e logarithm transformed scores were used, the saliency by group interaction approached significance, $F$ (1, 50) = 3.48, $p$ = .068, $MS_e$ = .158; all other results remained unchanged.

The above interaction resulted from the fact that the RD group made more errors (the mean difference 4.6%) with target words coming from the high-context saliency story than they did with target words coming from the low-context saliency story whereas the same was not true for the ND group (mean difference 0.08%). The RD group's difference between the high-and low-context saliency conditions approached significance, *F* (1, 24) = 4.17, *p* = .052, $MS_e$ = 127. When the exclusive data set's base-e logarithm transformed scores were used, the RD group's difference between the high salient and low salient condition no longer approached significance, *F* (1, 24) = 2.92, *p* = .102, $MS_e$ = .153.

In sum, no significant main effect of saliency was observed. However, Group by Saliency interaction was significant when the exclusive data set was used, suggesting that saliency may have a different effect on the performance of high-functioning dyslexics and normal adult readers for correctly primed target words. More specifically, HPDDs made more errors with target words coming from the high-salient story.

*Priming by Saliency.* A mixed model ANOVA with inclusive data set error rate as the dependent variable showed a significant Priming by Saliency interaction, *F* (1, 54) = 6.27, *p* = .015, $MS_e$ = 61.97, but no significant three-way interaction between Group, Priming, and Saliency, *F* (1, 54) = .37, *p* = .541, $MS_e$ = 61.97. When the data were transformed into a base-e logarithm, the Priming by Saliency interaction was no longer significant, *F* (1, 54) = 1.84, *p* = .181, $MS_e$ = .555, and the three-way interaction remained non-significant. When the exclusive data set was used, the Priming by Saliency interaction was again significant, *F* (1, 54) = 5.34, *p* = .025, $MS_e$ = 285.44, and the three-way interaction was not, *F* (1, 54) = .04, *p* = .905, $MS_e$ = 285.44. As with the inclusive data set, when the data were transformed into a base-e logarithm, the Priming by Saliency interaction was no longer significant. Figures 5-1a and 5-1b display the effect of saliency separately for the two priming conditions for the inclusive and exclusive data sets respectively. Both figures indicate that the nonprimed words were affected more than the primed words by the saliency of the story. In addition, while the participants made more errors with non-primed words from the highly salient story, the opposite was true for the primed words. However, as the interaction effects were not significant with transformed scores, it is possible that the values in Figures 5-1a and 5-1b are unduly affected by a small number of outlying cases.

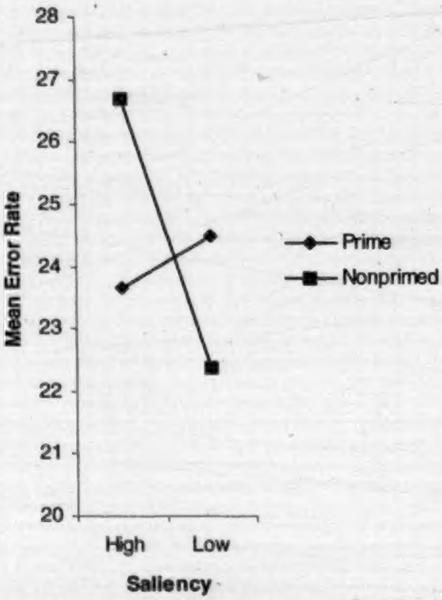

*Figure 5-1a.* The effect of priming by saliency on error rate (displayed in percentages) using the inclusive data set

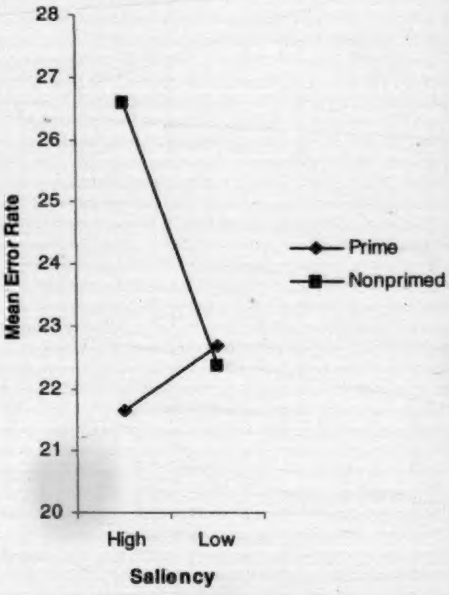

*Figure 5-1b.* The effect of priming by saliency on error rate (displayed in percentages) using the exclusive data set.

### *Recognition Speed*

Table 5-3 (inclusive data set) and Table 5-4 (exclusive data set) display the RD and ND groups' recognition speed means, standard deviations, maximum and minimum values (in milliseconds) for each context condition. A mixed model ANOVA with the inclusive data recognition speed as the dependent variable showed no significant main effect of Group, $F(1, 54) = 1.31, p = .257, MS_e = 93003.835$. When the exclusive data set was used, the results remained unchanged, $F(1, 54) = 1.73, p = .194, MS_e = 84814.668$. For both data sets the results remained unchanged when the data were transformed into a base-e logarithm.

Table 5-3

*Experiment 3: The Mean, Standard Deviation, Maximum and Minimum Reaction Times in Milliseconds for each Context Condition (Inclusive Data Set)*

| | RD Group ($n = 25$) | | | ND Group ($n = 31$) | | |
|---|---|---|---|---|---|---|
| Condition | Mean (*SD*) | Min. | Max. | Mean (*SD*) | Min. | Max. |
| H-CS NP RT | 1456<br>(476) | 770 | 2385 | 1195<br>(259) | 769 | 1949 |
| H-CS P RT | 1394<br>(367) | 829 | 2367 | 1292<br>(375) | 777 | 2349 |
| L-CS NP RT | 1262<br>(342) | 672 | 2180 | 1184<br>(240) | 738 | 1682 |
| L-CS P RT | 1364<br>(353) | 690 | 2021 | 1430<br>(366) | 926 | 2334 |

*Note*. RD = participants with a history of reading difficulties; ND = participants with no history of reading difficulties; H-CS NP RT = H-CS non-primed reaction time; H-CS P RT = H-CS primed reaction time; L-CS NP RT = L-CS non-primed reaction time; L-CS P RT = L-CS primed reaction time.

Table 5-4

*The Mean, Standard Deviation, Maximum and Minimum Reaction Times in Milliseconds for each Context Condition (Exclusive Data Set)*

| | RD Group ($n = 25$) | | | ND Group ($n = 31$) | | |
|---|---|---|---|---|---|---|
| Condition | Mean<br>(*SD*) | Min. | Max. | Mean<br>(*SD*) | Min. | Max. |
| H-CS NP RT | 1456<br>(476) | 770 | 2385 | 1195<br>(259) | 769 | 1949 |
| H-CS P RT | 1336<br>(285) | 879 | 1838 | 1263<br>(348) | 771 | 2187 |
| L-CS NP RT | 1262<br>(342) | 672 | 2180 | 1184<br>(240) | 738 | 1682 |
| L-CS P RT | 1371<br>(385) | 1532 | 536 | 1371<br>(377) | 773 | 2148 |

*Note*. RD = participants with a history of reading difficulties; ND = participants with no history of reading difficulties; H-CS NP RT = H-CS non-primed reaction time;; H-CS P RT = H-CS primed reaction time; L-CS NP RT = L-CS non-primed reaction time; L-CS P RT = L-CS primed reaction time.

*Priming*. A mixed model ANOVA with the inclusive data recognition speed as the dependent variable showed a significant main effect of Priming, $F\ (1, 54) = 11.12$, $p = .002$, $MS_e = 45409.89$, as well as a significant Priming by Group interaction, $F\ (1, 54) = 6.96$, $p = .011$, $MS_e = 45409.89$. When the exclusive data set was used, the results remained unchanged. When the data were transformed into a base-e logarithm, the results also remained unchanged for both the inclusive and exclusive data sets.

The above interactions resulted from the fact that the RD group recognized primed and non-primed target words at the same speed (mean difference 20 ms), whereas the ND group was significantly, $F$ (1, 30) = 24.72, $p < .001$, $MS_e = 36689.69$, faster with the non-primed target words (mean difference 171 ms). When the exclusive data set was used, the results remained essentially the same. Furthermore, the results did not change when the base-e logarithm transformed scores were used.

In sum, the effect of priming on the recognition speed was not the same for the two groups.

*Saliency.* A mixed model ANOVA with the inclusive data recognition speed as the dependent variable showed no significant main effect of Saliency, $F$ (1, 54) = .82, $p$ = .368, $MS_e = 38992.28$, but the Saliency by Group interaction was significant, $F$ (1, 54) = 10.93, $p = .002$, $MS_e = 38992.28$. When the data were transformed into a base-e logarithm, the results remained unchanged. The exclusive data set generated similar results with a non-significant main effect of saliency, $F$ (1, 54) = .31, $p = .579$, $MS_e$ = 42947.14, and significant saliency by group interaction, $F$ (1, 54) = 5.31, $p = .025$, $MS$= 42947.14. The results did not vary when the base-e logarithm transformed scores were used.

The above interactions resulted from the fact that the RD group's performance in the high salient condition was significantly slower, $F$ (1, 24) = 6.40, $p = .018$, $MS_e$ = 48840.84, than in the low salient condition (difference of 112 ms), whereas for the ND group, the difference (64 ms) between the two conditions was to the opposite direction and approached significance, $F$ (1, 30) = 4.04, $p = .054$, $MS_e = 31113.34$. When the exclusive data set was used, the RD group no longer showed a significant difference (80 ms) between the high salient and low salient conditions, $F\ (1, 24) = 3.07$, $p = .093$, $MS_e = 25934.71$, nor did the ND group, $F\ (1, 30) = 2.05$, $p = .163$, $MS_e = 17904.65$ (with a difference of 49 ms). However, these differences were again to the opposite direction.

In sum, the two groups were affected differently by the saliency of the stories. Examination of the mean differences suggests that the RD group exhibited an inhibition effect in the high salient condition whereas the ND group exhibited a small facilitation effect.

*Priming by Saliency.* A mixed model ANOVA with the inclusive data showed a significant Priming by Saliency interaction, $F\ (1,54) = 10.25$, $p = .002$, $MS_e = 132447.19$, but the three-way interaction between Group, Priming, and Saliency was not significant, $F\ (1,54) = .03$, $p = .870$, $MS_e = 132447{,}19$. When the data were transformed into a base-e logarithm, the results remained unchanged. When the exclusive data set was used, the Priming by Saliency interaction remained significant, $F\ (1,54) = 9.12$, $p = .004$, $MS_e = 182957.36$, and the three-way interaction remained non-significant, $F\ (1,54) = .92$, $p = .342$, $MS_e = 182857.36$. As with the inclusive data set, when the data were transformed into a base-e logarithm, the results remained unchanged.

Figures 5-2a and 5-2b display the effect of saliency separately for the two priming conditions for the inclusive and exclusive data sets, respectively. Both figures indicate that the effect of priming was limited to the low saliency condition.

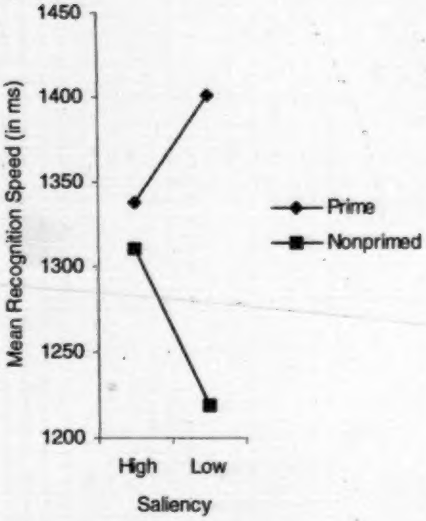

*Figure 5-2a.* The effect of priming by saliency on recognition speed (in milliseconds) using the inclusive data set.

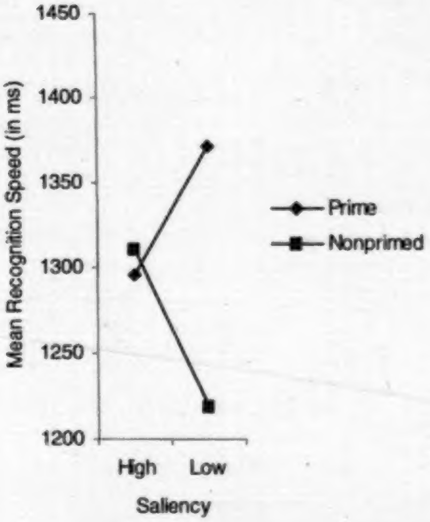

*Figure 5-2b.* The effect of priming by saliency on recognition speed (in milliseconds) using the exclusive data set.

## Discussion

When the priming effect was based on contextual-only rather than contextual-semantic relationships between the primes and the target words, neither the HPDDs nor the normally reading participants showed any differences in error rates. For the normally reading participants, this finding replicates Charwarski and Sternberg's (1993) results. In terms of recognition speed, contextual-only priming did have an effect on the performance of normally reading participants but not on the performance of HPDDs. Both groups responded faster to the non-primed conditions than to the primed conditions. The difference was significant, however, only for the ND group. These results are contrary to Charwarski and Sternberg's findings of no main effect of priming on recognition speeds. In their study, priming facilitated the participants' recognition speed of words from the H-CS story and inhibited their recognition of words from the L-CS story. In the current study, the inhibition effect on words from the L-CS story was found but the facilitation effect for the words from H-CS story was not observed. These results appear to suggest that the lack of a facilitation effect for the RD group in Experiments 1 and 2 may not be explained by a naming speed ceiling effect because when the restraints of verbal naming a word was replaced with a "yes/no" decision task, the RD group still did not experience a facilitation effect.

With regards to saliency, no significant main effects were found, similar to Charwarski and Sternberg's (1993) findings. However, the effect of saliency on the speed that the participants recognized the words was clearly different for the two groups. The significant saliency by group interaction that was found with both the inclusive and exclusive data sets may be attributed to the fact that the ND group, like Charwarski and Sternberg's participants, responded faster (but not significantly faster) to words from the H-CS story, while the RD group responded faster to words from the L-CS story. These within-group differences were not robust in that only with the inclusive data set was the difference between the saliency conditions significant for the RD group. There were no significant differences between the saliency conditions for the ND group.

Saliency had no main effect on the error rates, similar to Charwarski and Sternberg's (1993) results. The ND group had almost exactly the same error rate in both the high and low salient conditions, while the RD group had a non-significantly higher error rate in the high salient condition than in the low salient condition. Differences between the groups were not robust as the group by saliency interaction was significant only with the exclusive data set.

In terms of whether the high salience context dominated the overall recollection of the words from the stories and inhibited the contextual facilitation effect of the words presented in the low salience story, saliency insignificantly facilitated the ND group's ability to recognize words from the stories and inhibited the RD group's ability to recognize words from the stories. The ND group may have experienced facilitation because with the H-CS story not only do the priming words assist in determining whether a word was present in a story, but there may also have been residual priming from the story itself. In terms of context processing, the results imply that the ND group are using an interactive method of language processing. That is, for the H-CS story to interfere with the recognition of words for the L-CS story, the ND group had to be initially utilizing the stories' context. Furthermore, the lack of significant difference between the high and low salience contexts may also be a result of the continuous activation of and access to the stories' contexts. On the other hand, the fact that the RD group responded slower and made more errors in the H-CS conditions because the catchy and imaginative nature of the H-CS story made it more difficult for the RD group to read and understand thereby inhibiting its usefulness as a facilitator. This suggests that the RD group is utilizing context in a broader and more general sense rather than based on the semantic relationship of the primes. That is, RD group's use of context is based on their ability to comprehend the context, which suggests that the RD group is relying more heavily on a post-access integrated process and an interactive method of language processing.

Overall, there were no differences between the two groups in this task – the main effect of group was not significant for error rate or recognition speed. Furthermore, in terms of priming and saliency there was no significant difference between the two groups' error rates, but there was a difference in their word recognition speeds. Specifically, the high salient story inhibited the RD group's performance, regardless of data set, while priming had no significant effect on their performance. On the other hand, the high salient story facilitated the ND group's performance, while priming facilitated their accuracy but inhibited the speed at which they recognized words from the story.

# CHAPTER 6

# GENERAL DISCUSSION

It is generally accepted that context is used to some degree by all readers to assist word recognition. Several researchers (e.g., Aaron, 1989; Bruck, 1990, 1998; Ben-Dror et al., 1991; Stanovich & West, 1981, 1983) have suggested that individuals with developmental dyslexia increase their reliance on context in conjunction with the difficulty of the written passage. However, it has also been argued that rather than facilitating the word recognition process the use of context as a compensatory strategy may actually inhibit the word recognition process (e.g., Bruck, 1998). Few studies have examined high-performing developmental dyslexics (HPDDs) who show unexpectedly high levels of reading comprehension in the presence of continuing word reading problems. It is important to understand what role context plays in their reading process as this information can help to develop better teaching and intervention methods for those dyslexic readers whose reading comprehension remains deficient.

The current research examined how some specific aspects of context are used by HPDDs to assist word recognition. Past research has found that meaning and context are aids used by adults with developmental dyslexia (e.g., Aaron, 1989; Ben-Dror et al., 1991). While past research (e.g., Ben-Dror et al., 1991) has manipulated the context of the sentence prime, the current study expanded this research by also manipulating syntactic cues. Specifically, the current study examined (a) how semantic and syntactic manipulations of sentence primes affect the lexical access process, (b) if HPDDs differ from normal adult readers in how they use meaning frequency and context strength to facilitate word recognition and lexical ambiguity resolution, and (c) whether simply presenting the two words – the prime and the target – in the same story is enough to create a contextual connection between them when they are otherwise not semantically related.

The experimental group (RD) consisted of participants who reported significant reading difficulties on the elementary education section of the modified Adult Reading History Questionnaire (Parrila et al., 2003). Furthermore, the participants in the RD group were considered to be HPDDs as all of them were either current university students or recent graduates (less than six months at the time of initial testing). When compared to the control group (ND), who reported no reading problems, the RD group was poorer at recognizing and spelling words. They also had more difficulty naming real words and decoding pseudowords than the ND group. Finally, the RD group read significantly slower and had significantly lower timed reading comprehension scores than the ND group. It should be noted, however, that the significant difference in comprehension abilities disappeared when time constraints were removed.

Overall, the aforementioned characteristics of the RD group largely replicate previous research, which has found that while HPDDs can perform at par with normal readers on comprehension tasks, they do not perform at par on word reading and/or spelling tasks. We should also note that while the participants in this study were self-identified and many did not have a recent diagnosis of dyslexia, their performance was similar to that of participants with diagnosis of dyslexia in the earlier studies.

## Summary of the Main Results

Experiment 1 examined how semantic and syntactic manipulations of sentence context primes affected the lexical access process. This examination was accomplished through the use of sentence primes that had either (a) congruent, (b) incongruent, (c) subject-verb disrupted, (d) subject-verb neutral, or (e) subject-verb preserved relationship with the target word. When compared to the neutral condition, reliance on context should result in facilitation effect for the congruent condition and inhibition effect for the incongruent condition. The varying of the relationship between the subject noun and verb of the sentence prime affected the sentence prime's association with the target word. Therefore, if HPDDs rely on the integrated meaning of a context to assist word recognition, then facilitation should occur when the syntactic structure of a sentence prime has the strongest association with the target word.

The results of Experiment 1 indicated that congruent sentence prime significantly facilitated the ND group's performance, while the same was not true for the RD group. Group by condition interaction, however, was not significant in any of the comparisons indicating that differences in how the congruent context affected the performance of high-functioning dyslexics and normal adult readers were not reliable. In contrast, the incongruent sentence prime resulted in a significant group by condition interaction. Further analyses indicated that the incongruent context inhibited significantly only the RD group's performance. Finally, the two groups did not react differently to the manipulation of the syntactic structure of the prime sentences.

Significant inhibition effect for the RD but not for the ND group in the incongruent condition is in line with the prediction that the RD participants use context to predict the target word. The fact that neither the RD group's nor the ND group's naming speeds were significantly affected by the manipulation of syntax suggests that they are not processing the integrated meaning of the sentence as a whole, but rather it is the relationship between the content words that is contributing to the sentence's effectiveness as a prime. The subject-verb neutral condition may not have been an appropriate control condition because it had a considerably simpler sentence structure than the subject-verb preserved and the subject-verb disrupted conditions. Thus, it is unclear whether the results are due to the changes in the syntactic structure or are due to the complexity of the sentence. If the sentence structure of the neutral condition matched the sentence complexity of the subject-verb disrupted and the subject-verb preserved conditions, facilitation may have been observed. Therefore, the fact that no facilitation was observed may be an artefact of the experimental task.

In Experiment 2, HPDDs' use of context primes was examined further by investigating how sensitive the initial meaning activation of the homograph is to the prior context. To accomplish this, Experiment 2 used sentence primes that biased either the dominant meaning or the subordinate meaning of the target homograph, and target homographs that had either (a) a strong (high salience), (b) a weak (low salience), or (c) no semantic relationship with the sentences.

Experiment 2 found a robust main effect of target saliency for the HPDDs. Specifically, compared to the unrelated condition, the RD group's performance was significantly slower in the low-salient condition and insignificantly faster in the high-salient condition. In contrast, the ND group's performance was insignificantly slower in both the high- and low-salient conditions when compared to the unrelated condition. In addition, a robust homograph meaning frequency effect was found with the RD group benefiting significantly from the dominate condition when compared to the subordinate condition, while the ND group's performance was not significantly affected by the meaning frequency. Furthermore, the fact that the slower naming times remained despite matching subgroups of RD and ND participants based on their no-context naming speed suggests that the RD group's slower reading rate and weaker decoding skills did not affect their use of context. Thus, results of Experiment 2 clearly indicate that HPDDs' word recognition is sensitive to manipulations of context strength and meaning frequency.

Finally, while Experiments 1 and 2 examined the effect of context by looking at different mechanisms of semantic priming, Experiment 3 examined whether simply presenting the two words – the prime and the target – in the same story is enough to create a contextual connection between them when they are otherwise not semantically related. In addition, Experiment 3 examined the effect of general contextual priming. This was accomplished by examining responses to primed and non-primed target words from stories that were either (a) imaginative and catchy (high-context saliency; H-CS) and (b) common and simple (low-context saliency; L-CS). Finally, Experiment 3 used a different response mode than Experiments 1 and 2: rather than naming the target words, the participants merely made a "yes" or "no" decision, by pressing one of two keyboard keys, as to whether a word had appeared in one of the two stories presented.

The results showed that the main effect of group was not significant for either the error rate or the recognition speed. However, the results indicated that the effect of contextual priming on recognition speed and error rate differed for the two groups. Specifically, the high salient story facilitated the ND group's response speed, while priming in general facilitated their response accuracy but inhibited the speed at which they recognized words from the two stories. On the other hand, the RD group responded slower and made more errors in the high context-saliency condition than in the low context-saliency condition. One possible explanation of this result is that the content of the high context-saliency story made it more difficult for the RD group to read and understand, thereby inhibiting its usefulness as a facilitator. If the RD group's ability to quickly comprehend the context affects its usefulness as a prime, it is likely that they may be using context in a broader and more general sense rather than relying on the semantic relationships between the specific priming words and the targets.

Overall, in terms of context being used as a compensatory strategy the results of the current study suggest that (a) HPDDs' word processing is context sensitive, (b) the slower reading rates and weaker decoding skills of HPDDs are not solely responsible for the differences in context use, and (c) HPDDs' use of context may be based on their ability to comprehend the context as a whole and not just on the relationship between individual words.

## Modular vs. Interactive Models of Language Processing

Modular models of language processing argue that an integrated sentence level representation is not able to facilitate lexical access; rather, facilitation results from lexical-lexical priming. That is, the extent to which a target word is primed coincides with whether the context contains a single word that is semantically associated with the target word. Interactive models of language processing, on the other hand, argue that the occurrence of facilitation in a congruent sentence context may be attributed to the integrated sentence level representation. Past research (i.e., Duffy et al., 1989) has suggested that if the reading abilities of adults who do not have reading difficulties may be explained by modular combination models, then in situations similar to Experiment 1 where the semantic and syntactic structure of sentence primes were manipulated (e.g., the relationship between the subject noun and the subject verb and the target word) all contextual conditions would facilitate performance equally and no significant inhibition effect would occur. This may be speculated because despite changes in semantic and syntactical structure the context continues to contain a single word that is semantically associated with the target word. In Experiment 1 the ND group experienced significant facilitation and no significant inhibition effects, which appears to support the supposition that the reading abilities of individuals without reading difficulties may best be explained by a modular model of language processing.

On the other hand, since individuals with developmental dyslexia have weaker word recognition processes, it may be expected that the RD group would experience a larger facilitation effect when there is a strong association between the subject noun and verb and the target word (i.e., the congruent and subject-verb preserved conditions of Experiment 1) than when the association between the noun and the verb is disrupted (i.e., the subject-verb disrupted condition of Experiment 1). Such an occurrence would favour an interactive model of language processing because lexical access is being guided by the prior context. The presence of the interactive model of language processing would also be indicated by the occurrence of an inhibition effect when there was no relationship between the context and the target word (i.e., incongruent condition of Experiment 1). The results of Experiment 1 indicated that the RD group experienced a significant inhibition effect but no significant facilitation effects. Furthermore, since the inhibition by group interaction remained significant when the participants were matched either on word naming speed or on sentence reading speed suggests that it may be a characteristic of HPDDs rather than a result of slow decoding or text reading speed.

A possible explanation for the occurrence of inhibition without the presence of a facilitation effect may be that the weak decoding skills of the RD participants have resulted in the establishment of a naming speed ceiling effect. That is, the maximum naming speed achievable to the RD participants is at least partly defined by the deficient lower level processing skills and no amount of contextual facilitation can increase it significantly. Such a ceiling effect would limit facilitation while still enabling inhibition to occur. However, the results of Experiment 3 indicate that when the restraints of verbally naming a word were replaced with a "yes/no" decision task, the RD group still did not experience a facilitation effect. Therefore the occurrence of inhibition without the presence of a facilitation effect cannot be attributed solely to their deficits in lower level processing skills.

The results of Experiment 1 appear to support the position that the ND group's word recognition abilities may best be described by a modular model, while the RD group's abilities may best be described by an interactive model. If, however, the modular model of language processing explains the performance of the ND participants and the interactive model the performance of the RD participants, the two groups should have reacted differently to the manipulations of the syntactic structure of the sentence primes. In Experiment 1, this was not the case when the subject-verb neutral condition was compared with the subject-verb disrupted and the subject-verb preserved context conditions. As previously stated, however, these results may be an artefact of the experimental task and not a real result.

In addition, in Experiment 2 the RD group experienced facilitation for the high-salient targets in the subordinate condition and inhibition for the low-salient targets in the dominant condition when compared to the unrelated condition. These results support Twilley and Dixon's (2000) supposition that context strength and meaning frequency influence meaning activation, and they are compatible with the reordered access model (Duffy et al., 2001). The reordered access model would suggest that the inhibition that occurred for the low-salient targets in the dominate condition implies that both the dominant and the subordinate meanings were activated resulting in competition and slower response times. Duffy et al. (2001) referred to this effect as the subordinate bias effect. Therefore, the results of Experiment 2 provide further support for the conclusion that the interactive models of language processing, specifically the reordered access model, best account for the reading processes of the HPDDs in the current study.

In general, the findings of this study appear to support Stanovich and West's (1983) argument that the reading process used by individuals who experience reading difficulties may best be described as interactive. More specifically, Duffy et al.'s (2001) reordered access model seems to provide an accurate account of the results observed in Experiment 2. Stanovich and West's (1981, 1983) original argument made the assumption that the lower level reading deficits experienced by developmental dyslexics (e.g., phonological processing, word reading) are compensated through a greater reliance on other levels of processing, such as contextual processing. Results of this study suggest that HPDDs' performance is affected more by context than the control group's performance. One possible manner in which this could be happening is that while reading the individuals with developmental dyslexia activate a broader and more general sense of the context to help them to access the appropriate meanings of individual words.

## Reading Comprehension

One of the main characteristics of individuals with developmental dyslexia is poor phonological processing abilities, which result in weaker and less automatic word recognition abilities. Due to this characteristic, HPDDs are assumed to be using their attentional capacity to aid their word recognition abilities through the use of provided contextual cues. It has been argued that the reading comprehension abilities of individuals with developmental dyslexia are hampered because their limited attentional capacity is consumed by word recognition processes leaving little to no capacity for the comprehension processes (Bruck, 1998; Stanovich & West, 1983).

In the current study, the standardized tests administered to the participants demonstrated that the RD group had considerably poorer decoding (WRMT-R Word Attack), word reading (WRMT-R Word Identification), and spelling (WRAT3-Spelling) abilities than the ND group. The RD group also had both a slower reading rate and a lower comprehension level in the Nelson–Denny Reading test than the ND group, which would appear to support the argument that less automatic word recognition abilities led to slower reading rates in individuals with developmental dyslexia that then results in decreased comprehension levels (Bruck, 1998; van der Leij & van Daal, 1999). However, when the time factor of the Nelson-Denny was removed by calculating percentage correct score, the RD group's comprehension levels were at par with the ND group, which suggests that when HPDDs are given the opportunity to read without time constraints their comprehension levels may not be affected by their continuing difficulties with word reading. This finding appears to coincide with Ehri's (1998) position that a reader's word recognition skills increase in conjunction with the amount of time given to the meaning of the text. The findings also imply that when the RD group was given a context to read, their comprehension was not affected by their difficulties in recognizing decontextualized words and nonwords or by limited attentional capacity, which counters van der Leij and van Daal's (1999) argument that the automatization of word recognition is an essential reading skill. Thus, although the HPDDs in this study displayed poor word decoding (and encoding) skills, it did not appear to affect their ability to comprehend written passages. However, it is not clear at this point why HPDDs are able to comprehend at a high level without having the lower level skills automatized, but some speculations can be drawn from the current study.

As previously stated, the results of the current study suggest that HPDDs may be using a broader and more global context to assist in word recognition rather than relying on the more narrow lexical-lexical priming. One possible manner in which this could occur is that while HPDDs read continuous text, they quickly generate a broad sense of the context. Within this broad context, the most relevant semantic features are then selected effectively and used, in combination with partial visual and phonological cues, to activate the right word and/or its precise meaning.

It is possible that the efficiency of HPDDs use of the proposed top-down processing may depend on pre-established schemas related to the context. That is, if the HPDDs already have a schema in place for the context, then they are able to quickly and efficiently suppress less relevant semantic features of the homographs, which in turn increases their sentence comprehension speed. Efficiency at inhibiting irrelevant information has been used to account for individual differences in reading comprehension (McNamara & McDaniel, 2004). In addition, an examination of how content knowledge affects suppression of contextually irrelevant meanings of homographs indicated that individuals with a strong knowledge base suppressed the irrelevant meaning quicker than those with a weaker knowledge base (McNamara & McDaniel, 2004). However, some research has indicated that individuals with developmental dyslexia are less able than normally reading participants to inhibit the processing of irrelevant contextual information when the task was unrelated to reading (Brosnan et al., 2002). There clearly is a need to examine inhibition in more detail with HPDDs using reading-related tasks and in terms of the proposed top-down model.

## LIMITATIONS OF THE STUDY

The following limitations should be noted when examining the results of the current study:

1. While the sample size of the current study may be considered large when compared to other research that has focused on this population, it was still relatively small and consisted of volunteers. As such, it may not be possible to generalize the results across the entire HPDD population.
2. The participants were self-identified and not all had received a formal diagnosis of dyslexia as children. Therefore the true extent of their past reading acquisition problems is unclear and we cannot rule out the possibility that many of the participants in the current study were those developmental dyslexics whose initial reading problems were not very severe.

3. The current study was completed in one university that draws its student population mainly from one Canadian province. As a result it is possible that local conditions such as the availability of support in high schools may have influenced which individuals with developmental dyslexia were able to attend the university.
4. The current study did not control for the attention difficulties which can coexist with reading difficulties. It is possible, therefore, that attention difficulties may have contributed to the effectiveness of the contextual cues because for the cues to be effective an individual must first be able to attend to them.
5. In Experiment 1 the lack of facilitation effects may suggest that the subject-verb neutral condition was not an appropriate control condition. Specifically, the subject-verb neutral condition had a considerably simpler sentence structure than subject-verb preserved and subject-verb disrupted conditions. If the sentence structures had matched, the subject-verb preserved and the subject-verb disrupted conditions may have generated a facilitation effect. Therefore, the fact that no facilitation was observed may be an artefact of the experimental task.
6. Experiment 2 did not control for stimulus onset asynchrony (SOA). Other research has suggested that when SOAs are short, facilitation occurs for both the dominant and subordinate meanings; however, when the SOAs are long, facilitation occurs for the dominant meaning, but not the subordinate meaning of the homograph (Nievas & Mari-Beffa, 2002;

Rayner & Frazier, 1989). It is plausible that the RD group had naturally longer SOAs, which may account for the significantly slower responses in the low-salient condition and the insignificantly faster responses in the high-salient condition. Further research controlling for SOA is necessary to determine its effect on the results of Experiment 2.

7. None of the experimental tasks controlled for how carefully and thoroughly the participants read the context primes. It is possible that the results do not reflect the use of context primes but rather reflect other processes.
8. Finally, it should be noted that this was an experimental study and further research is necessary to determine how well the current results transfer to everyday reading situations.

## FUTURE DIRECTIONS

Based on the results and limitations of the current study the following areas of future research are recommended:

1. The results of the current study suggest that the HPDDs were using an interactive model of language processing, while the control group were using a modular model of language processing. If the two groups were in fact using different models of language processing, they should have reacted differently to the manipulation of the sentence primes' syntactic structure. The results did not indicate different reactions to the manipulation. Further research is necessary, therefore, to determine

whether the current null finding is an artefact of the experimental task used in Experiment 1.

2. The current study should be replicated with the inclusion of a new experimental group consisting of individuals with developmental dyslexia who have not achieved academic success. The inclusion of such a group would enable the determination of whether the performance generated by the HPPDs in the current study is unique to them alone or is it also representative of individuals with developmental dyslexia who have not achieved academic success.
3. If the ability to inhibit irrelevant information influences reading comprehension (e.g., McNamara & McDaniel, 2004), then it would be of interest to further examine the inhibition abilities of HPPDs. In the current study the HPDDs displayed inhibition effects while the normally reading adults did not, indicating that they processed the context differently. It may be possible that the occurrence of the inhibition effects may be related to HPDDs' ability to inhibit irrelevant information while processing text. Further research is necessary to address this possibility.
4. Finally, to gain further insight into the reading process of HPDDs further research needs to be done using experimental tasks that are more representative of the reading material found at the post-secondary education level.

# CONCLUSIONS

The results of this study demonstrate that HPDDs' word processing may be more context sensitive than the word processing of normally reading adults. Second, as demonstrated in Experiment 2 with a subgroup of participants who were matched on their no-context naming speed, HPDDs' use of context may not be solely attributed to their slower reading rates and weaker decoding skills. Third, the HPDDs' use of context may be based on their ability to comprehend the context on a whole and not on the relationship between individual words. Finally, in terms of language processing, the findings of the current study suggest that the HPDDs were processing context in a manner that corresponds to the interactive model of language processing, with the reordered access model (Duffy et al. 2001) providing the best account for the observed results.

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# APPENDIX A

## ELEMENTARY EDUCATION SECTION OF THE MODIFIED ADULT READING HISTORY QUESTIONNAIRE

Please circle the number of the response that most nearly describes your attitude or experience for each of the following questions or statements. If you think your response would be between numbers, place an "X" where you think it should be.

11. When you were in elementary school, which of the following most nearly describes *your parents'* attitude towards education?

| | | | | |
|---|---|---|---|---|
| **Education was important** | | | | **Education was not important** |
| 0 ________ | 1 ________ | 2 ________ | 3 ________ | 4 |

---

12. Which of the following most nearly describes *your* attitude toward school when you were in elementary school:

| | | | | |
|---|---|---|---|---|
| **Loved school; Favourite activity** | | | | **Hated school; tried to get out of going** |
| 0 ________ | 1 ________ | 2 ________ | 3 ________ | 4 |

---

13. How much difficulty did you have learning to read in elementary school?

| | | | | |
|---|---|---|---|---|
| **None** | | | | **A great deal** |
| 0 ________ | 1 ________ | 2 ________ | 3 ________ | 4 |

---

14. How much extra help did you need when learning to read in elementary school?

| | | | | |
|---|---|---|---|---|
| **No help** | **Help from: Friends** | **Teachers/ parents** | **Tutors or special class1 year** | **Tutors or special class2 or more years** |
| 0 ________ | 1 ________ | 2 ________ | 3 ________ | 4 |

---

15. Did you ever reverse the order of letters or numbers when you were a child?

**No**

**A great deal**

0 ____________ 1 ____________ 2 ____________ 3 ____________ 4

---

16. Did you have difficulty learning letter and/or colour names when you were a child?

**No**

**A great deal**

0 ____________ 1 ____________ 2 ____________ 3 ____________ 4

---

17. How would you compare your reading skill to that of others in your elementary classes?

**Above average**

**Average**

**Below average**

0 ____________ 1 ____________ 2 ____________ 3 ____________ 4

---

18. All students struggle from time to time in elementary school. In comparison to your classmates, how much did you struggle to complete your work?

| | | | | |
|---|---|---|---|---|
| **Not at all** | **Less than most** | **About the same** | **More than most** | **Much more than most** |

0 ____________ 1 ____________ 2 ____________ 3 ____________ 4

---

19. Which of the following most nearly describes *your* attitude toward reading as a child?

**Very positive**

**Very negative**

0 ____________ 1 ____________ 2 ____________ 3 ____________ 4

---

20. When you were in elementary school, how much reading did you do for pleasure?

**A great deal**

**Some**

**None**

0 ____________ 1 ____________ 2 ____________ 3 ____________ 4

21. How would you compare your reading speed in elementary school with that of your classmates?

| | | | | |
|---|---|---|---|---|
| **Above average** | | **Average** | | **Below average** |
| 0 | 1 | 2 | 3 | 4 |

22. How much difficulty did you have learning to spell in elementary school?

| | | | | |
|---|---|---|---|---|
| **None** | | **Some** | | **A great deal** |
| 0 | 1 | 2 | 3 | 4 |

23. Did your parents ever consider having you repeat any grades in elementary school due to academic failure (not illness)?

| | | | | |
|---|---|---|---|---|
| **No** | **Talked about it but didn't do it** | **Repeated 1 grade** | **Repeated 2 grades** | **Repeated more than 2 grades** |
| 0 | 1 | 2 | 3 | 4 |

24. When you were in elementary school, how many books did you read for pleasure each *year*?

| | | | | |
|---|---|---|---|---|
| **More than 10** | **6-10** | **2-5** | **1-2** | **None** |
| 0 | 1 | 2 | 3 | 4 |

25. How many comic books did you read for pleasure each *year*?

| | | | | |
|---|---|---|---|---|
| **More than 10** | **6-10** | **2-5** | **1-2** | **None** |
| 0 | 1 | 2 | 3 | 4 |

# APPENDIX B

## Context sentences and targets words used in Experiment 1

### *Congruent*

1. The wine was served from the decanter.
2. The housewife waxed the linoleum.
3. The mortician examined the cadaver.
4. The baker smelled the aroma.
5. The fisherman exceeded the quota.
6. The accountant balanced the ledger.
7. The team won the tournament.
8. The preacher spread the gospel.
9. The painter fell off the scaffold.
10. The train went over the trestle.
11. The artist painted the mural.
12. The couple adopted the orphan.
13. The barber trimmed the mustache.
14. The hotel's guests liked the accommodations.
15. The carpenter drove in the spike.
16. The waiter handed them the menu.
17. The interpreter knew the dialect.
18. The bartender served the cocktails.
19. The pianist played at the recital.
20. The sun was totally hidden by the eclipse.

### *Incongruent*

1. The politician appealed to the decanter.
2. The wine was served from the linoleum.
3. The fisherman exceeded the cadaver.
4. The accountant balanced the aroma.
5. The baker smelled the quota.
6. The housewife waxed the ledger.
7. The mortician examined the tournament.
8. The biologist examined the gospel.
9. The tree was uprooted in the scaffold.
10. The country was ruled by the trestle.
11. The train went over the mural.
12. The crook was sent to the orphan.
13. The house was destroyed by the mustache.
14. The barber trimmed the accommodations.
15. The hotel's guests like the spike.
16. The carpenter drove in the menu.
17. The waiter handed them the dialect.
18. The bomb destroyed everything in the cocktails.
19. The skier was buried in the recital.
20. The game warden fined the eclipse.

### *Subject-verb disrupted*

1. Juice replaced the wine and was served from the decanter.

2. The boy who watched the housewife waxed the linoleum.
3. The man who knew the mortician well examined the cadaver.
4. The child smiled at the baker and smelled the aroma.
5. The man who stopped the fisherman exceeded the quota.
6. The daughter of the accountant balanced the ledger.
7. The reporter who took pictures of the team won the tournament.
8. The tailor outfitted the preacher and spread the gospel.
9. While watching the painter she fell off the scaffold.
10. The boy waved to the train and went over the trestle.
11. The person who argued with the artist painted the mural.
12. The man lied about the couple and adopted the orphan.
13. While talking to the barber she trimmed the mustache.
14. The man who knew the hotel's guests well liked the accommodations.
15. The man left the carpenter and drove in the spike.
16. The waiter was handed the menu.
17. The man who painted the interpreter knew the dialect.
18. The woman who knew the bartender well served the cocktails.
19. The girl ignored the pianist and played at the recital.
20. The cloud near the sun was totally hidden by the eclipse.

*Subject-verb neutral*

1. The stuff was placed near the decanter.
2. The person liked the linoleum.
3. The people noticed the cadaver.

4. The women knew the aroma.
5. The person forgot the quota.
6. The woman wanted the ledger.
7. The boys saw the tournament.
8. The people liked the gospel.
9. The person looked at the scaffold.
10. The thing was near the trestle.
11. The person wanted the mural.
12. The people ignored the orphan.
13. The woman saw the mustache.
14. The new people wanted the accommodations.
15. The people looked at the spike.
16. The man looked at the menu.
17. The people liked the dialect.
18. The woman wanted the cocktails.
19. The woman was at the recital.
20. The thing was not affected by the eclipse.

### *Subject-verb preserved*

1. Juice replaced the wine which was served from the decanter.
2. The boy watched the housewife wax the linoleum.
3. The man knew the mortician who examined the cadaver.
4. The child smiled as the baker smelled the aroma.
5. The man stopped the fisherman who exceeded the quota.

6. The daughter saw the accountant balance the ledger.
7. The reporter took pictures as the team won the tournament.
8. The tailor outfitted the preacher who spread the gospel.
9. While she watched him the painter fell off the scaffold.
10. The boy waved as the train went over the trestle.
11. The person argued with the artist who painted the mural.
12. The man lied about the couple who adopted the orphan.
13. While she talked to him the barber trimmed the mustache.
14. The man knew that the hotel's guests would like the accommodations.
15. The man left as the carpenter drove in the spike.
16. The waiter handed them the menu.
17. The man painted the interpreter who knew the dialect.
18. The woman knew that the bartender served the cocktails.
19. The girl ignored the pianist who played at the recital.
20. The clouds neared the sun which was totally hidden by the eclipse.

# Appendix C

The word length, word frequency, bigram frequency and number of syllables for the target words used in the context conditions of Experiment 1

| **Word** | **Word Length** | **Kucera-Francis Frequency** | **Mean Bigram Frequency** | **No. of Syllables** |
|---|---|---|---|---|
| accommodations | 14 | 8 | 1979 | 5 |
| aroma | 5 | 3 | 2001 | 3 |
| cadaver | 7 | 1 | 1972 | 3 |
| cocktails | 9 | 2 | 1090 | 2 |
| decanter | 8 |  | 3252 | 3 |
| dialect | 7 | 10 | 1986 | 3 |
| eclipse | 7 | 2 | 1249 | 2 |
| gospel | 6 | 13 | 1086 | 2 |
| ledger | 6 | 7 | 3082 | 2 |
| linoleum | 8 | 1 | 2276 | 4 |
| menu | 4 | 5 | 1943 | 2 |
| mural | 5 | 1 | 1971 | 2 |
| mustache | 8 | 5 | 1714 | 2 |
| orphan | 6 | 1 | 1640 | 2 |
| quota | 5 | 4 | 850 | 2 |
| recital | 7 | 8 | 2325 | 3 |
| scaffold | 8 | 6 | 790 | 2 |
| spike | 5 | 2 | 660 | 1 |
| tournament | 10 | 20 | 1757 | 3 |
| trestle | 7 | 1 | 3020 | 2 |
| **Mean** | 7.10 | 5.26 | 1832.15 | 2.5 |
| ***SD*** | 2.22 | 4.99 | 742.78 | .89 |

# APPENDIX D

The word length, word frequency, bigram frequency and number of syllables for the no-context condition in Experiment 2.

| Word | Word Length | Kucera-Francis Frequency | Mean Bigram Frequency | No. of Syllables |
|---|---|---|---|---|
| brandy | 6 | 7 | 1816.00 | 2 |
| check | 5 | 88 | 1378.00 | 1 |
| chicken | 7 | 37 | 1759.00 | 2 |
| context | 7 | 35 | 2537.00 | 2 |
| cord | 4 | 6 | 1952.00 | 1 |
| curb | 4 | 13 | 758.00 | 1 |
| ditty | 5 | 1 | 1357.00 | 2 |
| drop | 4 | 59 | 1097.00 | 1 |
| effort | 6 | 145 | 1039.00 | 2 |
| flannel | 7 | 4 | 1725.00 | 2 |
| free | 4 | 260 | 1930.00 | 1 |
| infest | 6 | 1 | 3174.00 | 2 |
| luck | 4 | 47 | 656.00 | 1 |
| market | 6 | 155 | 1433.00 | 2 |
| marsh | 5 | 4 | 1852.00 | 1 |
| middle | 6 | 118 | 1230.00 | 2 |
| mist | 4 | 14 | 2565.00 | 1 |
| navy | 4 | 37 | 606.00 | 2 |
| nerve | 5 | 12 | 2639.00 | 1 |
| peril | 5 | 8 | 3033.00 | 2 |
| plant | 5 | 125 | 2324.00 | 1 |
| pump | 4 | 11 | 635.00 | 1 |
| radish | 6 | 8 | 2018.00 | 2 |
| smog | 4 | 1 | 665.00 | 1 |
| stench | 6 | 1 | 2938.00 | 1 |
| tail | 4 | 24 | 1409.00 | 1 |
| take | 4 | 611 | 1035.00 | 1 |
| victor | 6 | 23 | 1666.00 | 2 |
| weasel | 6 | 1 | 1503.00 | 2 |
| wedding | 7 | 32 | 2978.00 | 2 |
| **Mean** | 5.2 | 62.93 | 1723.57 | 1.5 |
| ***SD*** | 1.10 | 119.93 | 773.20 | .51 |

# APPENDIX E

The word length, word frequency, bigram frequency and number of syllables for the target words used in the context conditions of Experiment 2

| Sentence Prime | Context Condition | Word | Word Length | Kucera-Francis Frequency | Mean Bigram Frequency | No. of Syllables |
|---|---|---|---|---|---|---|
| He heard a bark. | DH | DOG | 3.00 | 75.00 | 547.00 | 1.00 |
| He saw the bear. | DH | BIG | 3.00 | 360.00 | 717.00 | 1.00 |
| He asked for the bill. | DH | CHECK | 5.00 | 88.00 | 1378.00 | 1.00 |
| He went into the cell. | DH | PRISON | 6.00 | 42.00 | 2473.00 | 2.00 |
| I saw a steer. | DH | COW | 3.00 | 29.00 | 1580.00 | 1.00 |
| It was hard to park. | DH | CAR | 3.00 | 274.00 | 2384.00 | 1.00 |
| She had a rash. | DH | RED | 3.00 | 197.00 | 4514.00 | 1.00 |
| They knew they were right. | DH | CORRECT | 7.00 | 52.00 | 2131.00 | 2.00 |
| They brought a ring. | DH | GOLD | 4.00 | 52.00 | 663.00 | 1.00 |
| It began to shed. | DH | HAIR | 4.00 | 148.00 | 958.00 | 1.00 |
| **Mean** | | | 4.10 | 131.70 | 1734.50 | 1.20 |
| ***SD*** | | | 1.45 | 112.21 | 1210.95 | .42 |
| He heard a bark. | DL | ANIMAL | 6.00 | 68.00 | 2126.00 | 3.00 |
| He saw the bear. | DL | LARGE | 5.00 | 361.00 | 1625.00 | 1.00 |
| He asked for the bill. | DL | DINNER | 6.00 | 91.00 | 3515.00 | 2.00 |
| He went into the cell. | DL | BLOCK | 5.00 | 66.00 | 1060.00 | 1.00 |
| I saw a steer. | DL | CALF | 4.00 | 11.00 | 1656.00 | 1.00 |
| It was hard to park. | DL | STREET | 6.00 | 244.00 | 2404.00 | 1.00 |
| She had a rash. | DL | SPREAD | 6.00 | 83.00 | 1916.00 | 1.00 |
| They knew they were right. | DL | PROPER | 6.00 | 95.00 | 2413.00 | 2.00 |

| Sentence Prime | Context Condition | Word | Word Length | Kucera-Francis Frequency | Mean Bigram Frequency | No. of Syllables |
|---|---|---|---|---|---|---|
| They brought a ring. | DL | PROMISE | 7.00 | 45.00 | 1811.00 | 2.00 |
| It began to shed. | DL | SUMMER | 6.00 | 134.00 | 1955.00 | 2.00 |
| **Mean** | | | 5.70 | 119.80 | 2048.10 | 1.60 |
| ***SD*** | | | .82 | 105.21 | 650.56 | .70 |
| He bought a chest. | SH | WOOD | 4.00 | 55.00 | 600.00 | 1.00 |
| He memorized the drill. | SH | PRACTICE | 8.00 | 94.00 | 2251.00 | 2.00 |
| You have to be in shape to fence. | SH | SWORD | 5.00 | 7.00 | 979.00 | 1.00 |
| He worked on it with a file. | SH | ROUGH | 5.00 | 41.00 | 1153.00 | 1.00 |
| I went to the firm. | SH | BUSINESS | 8.00 | 392.00 | 2702.00 | 2.00 |
| He was considered a nut. | SH | CRAZY | 5.00 | 34.00 | 1009.00 | 2.00 |
| Don't do anything rash. | SH | STUPID | 6.00 | 24.00 | 1275.00 | 2.00 |
| She handed him a roll. | SH | BREAD | 5.00 | 41.00 | 1996.00 | 1.00 |
| They all rose. | SH | STOOD | 5.00 | 212.00 | 1598.00 | 1.00 |
| A lot was at stake. | SH | RISK | 4.00 | 54.00 | 1953.00 | 1.00 |
| **Mean** | | | 5.50 | 95.40 | 1551.60 | 1.40 |
| ***SD*** | | | 1.43 | 119.03 | 661.36 | .51 |
| He bought a chest. | SL | BEDROOM | 7.00 | 52.00 | 1671.00 | 2.00 |
| He memorized the drill. | SL | MARCH | 5.00 | 120.00 | 1649.00 | 1.00 |
| You have to be in shape to fence. | SL | KNIGHT | 6.00 | 18.00 | 650.00 | 1.00 |
| He worked on it with a file. | SL | INSTRUMENT | 10.00 | 47.00 | 2654.00 | 3.00 |
| I went to the firm. | SL | PRESIDENT | 9.00 | 382.00 | 2794.00 | 2.00 |
| He was considered a nut. | SL | INSTITUTION | 11.00 | 41.00 | 3286.00 | 4.00 |
| Don't do anything rash. | SL | ABRUPT | 6.00 | 18.00 | 603.00 | 2.00 |
| She handed him a roll. | SL | BREAKFAST | 9.00 | 53.00 | 1590.00 | 2.00 |
| They all rose. | SL | COURT | 5.00 | 230.00 | 1626.00 | 1.00 |

| Sentence Prime | Context Condition | Word | Word Length | Kucera-Francis Frequency | Mean Bigram Frequency | No. of Syllables |
|---|---|---|---|---|---|---|
| A lot was at stake. | SL | WIN | 3.00 | 55.00 | 3682.00 | 1.00 |
| **Mean** | | | 7.10 | 101.60 | 2020.50 | 1.90 |
| ***SD*** | | | 2.56 | 116.94 | 1046.17 | .99 |
| She sat at the organ. | DUR | BOOK | 4.00 | 193.00 | 640.00 | 1.00 |
| I saw a duck. | DUR | BELOW | 5.00 | 145.00 | 1187.00 | 2.00 |
| It jumped on her lap. | DUR | NOTE | 4.00 | 127.00 | 2033.00 | 1.00 |
| She was very plain. | DUR | THROW | 5.00 | 42.00 | 1101.00 | 1.00 |
| He hurt his back. | DUR | SUPPORT | 7.00 | 180.00 | 1101.00 | 2.00 |
| She picked up the stick. | DUR | DRIVE | 5.00 | 105.00 | 1511.00 | 1.00 |
| It was made of straw. | DUR | STAY | 4.00 | 113.00 | 1955.00 | 1.00 |
| He bought a suit. | DUR | PLASTIC | 7.00 | 31.00 | 2480.00 | 2.00 |
| It must be spring. | DUR | COURT | 5.00 | 230.00 | 1626.00 | 1.00 |
| It lasted a second. | DUR | BIRD | 4.00 | 31.00 | 684.00 | 1.00 |
| **Mean** | | | 5.00 | 119.70 | 1431.80 | 1.30 |
| ***SD*** | | | 1.15 | 69.84 | 600.26 | .48 |
| The man asked him to step back. | SUR | SPINE | 5.00 | 6.00 | 2705.00 | 1.00 |
| The disease damaged an organ. | SUR | TEXT | 4.00 | 60.00 | 1708.00 | 1.00 |
| I had to duck. | SUR | HILL | 4.00 | 72.00 | 1378.00 | 1.00 |
| He will pass her on the next lap. | SUR | ADDRESS | 7.00 | 77.00 | 2043.00 | 2.00 |
| They lived on the plain. | SUR | INSIDE | 6.00 | 174.00 | 2782.00 | 2.00 |
| It would not stick. | SUR | POWER | 5.00 | 342.00 | 2102.00 | 2.00 |
| He asked for a straw. | SUR | PASTE | 5.00 | 10.00 | 2628.00 | 1.00 |
| They were involved in a suit. | SUR | NARROW | 6.00 | 63.00 | 1560.00 | 2.00 |
| She sat on a spring | SUR | CIVIL | 5.00 | 91.00 | 1015.00 | 2.00 |
| He came in second. | SUR | WHITE | 5.00 | 365.00 | 1973.00 | 1.00 |

| Sentence Prime | Context Condition | Word | Word Length | Kucera-Francis Frequency | Mean Bigram Frequency | No. of Syllables |
|---|---|---|---|---|---|---|
| **Mean** | | | 5.20 | 126.00 | 1989.40 | 1.5 |
| ***SD*** | | | 0.92 | 128.58 | 591.68 | .53 |
| **Overall Mean** | | | 5.43 | 115.70 | 1795.98 | 1.48 |
| **Overall *SD*** | | | 1.70 | 106.27 | 830.18 | .65 |

# APPENDIX F

## The stories used in Experiment 3

### *Low Contextual Saliency Story (L-CS)*

Imagine volunteering to be a surgeon, a pilot or a train engineer. Imagine spending some of your time doing what you aspired to do as a kid. I do. I am a volunteer firefighter. Obstacles such as diplomas and licenses usually stand between grownups and the fulfillment of their childhood dreams. The real world seldom accepts a kid's fantasy as an adult's credentials. But fire departments do, at least the majority that rely on the million-plus men and women who volunteer their services. I was smitten with the drama of firefighting at about the age of eight, when I started hanging around a firehouse in our neighborhood. I'd run errands to ingratiate myself with the men, and before long I was more or less adopted by the fire company. From then on, I dreamed of being a firefighter one day. I never outgrew the dream even though I chose another career. As an adult, I joined the volunteer fire department in my suburban town. I was issued gear, received training -- and then waited. Finally one evening it happened: there was a cellar fire in a house on the west side of town. I drove to the firehouse with adrenalin coursing through my veins, quickly donned my gear and held tight as the engine roared out of the firehouse, red lights twirling and siren wailing. There I was, living my boyhood dream! Thick smoke was billowing from the front door of the house. One veteran yelled, "Stay with me!" He grabbed the nozzle of a hose and ran inside. I followed, my heart racing. We started down the stairs, but I couldn't see anything. Suddenly I heard the crash of breaking glass and the roar of water as the nozzle was opened. We dropped to our knees and crawled forward. My mask was supposed to supply fresh air for 20 minutes, but I was sure that, at the rate I was sucking it in, I'd be lucky to last ten. "What the hell did I get myself into?" I wondered. Then the fire began to darken down. Beams of light penetrated the gloom as portable lamps were set up. Pieces of broken toys floated by in the inches-deep water. It got cool. The fire was out.

### *High Contextual Saliency Story (H-CS)*

I was 10 minutes late for the lecture. It was an introductory lecture on theoretical engineering entitled: "Basic operations on space." I ran down the hall and quietly passed through the door to Davies auditorium. I sat in a free seat in one of the middle rows. The audience was listening attentively, but with visible distance toward the substance of the lecture. At the front of auditorium, in the place where a large desk usually stood, there was now a stage. Beside Professor Jenkins there were three young people on the stage. I asked my neighbor what had happened up to now. He said that the professor randomly chose three students from the audience and asked them to help him illustrate his lecture. The students on the stage behaved strangely. They told their visions, took strange poses, but their acting synchronized very well with the talk. The professor said: "The world around us consists of three basic elements. They are: matter, space, and time. I am most interested in exploring, understanding, and manipulating space. During the course of the lectures I will give you some principles and examples of how we can gain control over space." Then he pointed out four students. They came to the stage and each greeted the professor with a kiss. He said that in order to possess control over space, one has to set matter and time free. At the same moment the illustrators regressed in time. Some of them regressed to their childhood, some of them even further, back to animals living in the primordial sea. After this preliminary part of the lecture, suddenly, as if at the same moment, all the persons on the stage changed their appearance. Now, they all wore ballet outfits with glittering hems. The girls wore black and they danced, like little girls, holding hands in a circle. The boys wore light outfits and they moved like crabs on sand. Leaning on hands and feet, with their abdomens up, they moved sideways. During the course of the play the actors commanded more and more space. Suddenly, more figures appeared in the auditorium. They wore similar costumes, but some of them had aerial, light wings attached to their costumes and some had colorful sashes. Now the ceiling opened and Davies auditorium became at least five times higher. Some actors, suspended on lines, flew above the heads of the audience. The supporting equipment was not hidden. Everybody could see under the ceiling the complicated construction of pipes and wheels which allowed movement in every possible direction. The professor, in a similar costume, also flew above the audience. First, he flew like a bird with his wings extended wide. Next, he started to vibrate vertically. When the amplitude of his vibration heightened he dissolved into several identical figures vibrating harmonically. At the same time, all the figures on the stage changed their human shape into undetermined matter that formed unusual shapes. For a moment they became big pieces of different fruits: bananas, kiwis, and oranges. They formed large, perpetually moving, three-colored fruit salad. Each piece lay on the floor of the stage side by side in the form of a fan, delicately trembling, then smoothly changing places, then rotating around the center. Leaving the auditorium after the lecture I wondered if anyone would let me Xerox their notes.

# APPENDIX G

## The word list from Experiment 3

| Word | Condition |
|---|---|
| drifted | UR |
| foliage | UR |
| gear | LCS NP |
| wars | UR |
| stage | HCS NP |
| fruits | HCS P |
| glittering | HCS P |
| web | UR |
| kiwis | HCS NP |
| danced | HCS P |
| shack | UR |
| camphor | UR |
| racing | LCS NP |
| cotton | UR |
| vibrate | HCS NP |
| Texas | UR |
| neat | UR |
| boyhood | LCS NP |
| drove | LCS P |
| engine | LCS P |
| married | UR |
| gurgle | UR |
| alleys | UR |
| adrenalin | LCS NP |
| charcoal | UR |
| tubes | UR |
| animals | HCS NP |
| soda | UR |
| Davies | HCS NP |
| wound | UR |
| drums | UR |
| hunted | UR |
| dirty | UR |
| smoke | LCS NP |
| licenses | LCS P |
| hose | LCS P |
| engineer | LCS P |
| temperate | UR |
| darken | LCS NP |

| Word | Condition |
|---|---|
| veteran | LCS P |
| trailer | UR |
| professor | HCS NP |
| bananas | HCS P |
| Mars | UR |
| slipping | UR |
| salad | HCS NP |
| worms | UR |
| anxious | UR |
| stove | UR |
| swiftness | UR |
| throttle | UR |
| lurched | UR |
| adult | LCS NP |
| town | LCS P |
| pillows | UR |
| whales | UR |
| visions | HCS NP |
| students | HCS P |
| amplitude | HCS P |
| wine | UR |
| oranges | HCS NP |
| space | HCS P |
| lecture | HCS P |
| regressed | HCS P |
| kerosene | UR |
| dwellings | UR |
| engineering | HCS NP |
| aerial | HCS P |
| placid | UR |
| firehouse | LCS NP |
| meowing | UR |
| silken | UR |
| statism | UR |
| whisky | UR |
| parked | UR |
| heart | LCS NP |
| siren | LCS P |
| imagine | LCS P |
| tobacco | UR |
| midnight | UR |
| solvency | UR |
| costumes | HCS NP |

| Word | Condition |
|---|---|
| audience | HCS P |
| kiss | HCS P |
| canals | UR |
| terrible | UR |
| sleek | UR |
| childhood | HCS NP |
| volume | UR |
| cool | LCS NP |
| purchased | UR |
| surgeon | LCS NP |
| suburban | LCS P |
| pigs | UR |
| locustus | UR |
| abdomens | HCS NP |
| pantries | UR |
| volunteer | LCS NP |
| twirling | LCS P |
| sheets | UR |
| whole | UR |
| water | LCS NP |
| joined | LCS P |
| career | LCS P |
| supply | LCS P |
| wool | UR |
| ballet | HCS NP |
| matter | HCS P |
| anteroom | UR |
| torches | UR |
| onions | UR |
| poses | HCS NP |
| suspended | HCS P |
| attire | UR |
| sucking | LCS NP |
| roared | LCS P |
| government | UR |
| breed | UR |
| heaped | UR |
| straw | UR |
| sashes | HCS NP |
| rosy | UR |
| hems | HCS NP |
| auditorium | HCS P |
| greeted | HCS P |

| Word | Condition |
|---|---|
| motorboat | UR |
| revere | UR |
| beams | LCS NP |
| outgrew | LCS P |
| diploma | LCS P |
| bell | UR |
| mask | LCS NP |
| department | LCS P |
| suite | UR |
| grocery | UR |
| crabs | HCS NP |
| dissolved | HCS P |
| atomic | UR |
| servants | UR |
| capsules | UR |
| mouths | UR |
| actors | HCS NP |
| piled | UR |
| towel | UR |
| smitten | LCS NP |
| nozzle | LCS P |
| credentials | LCS P |
| environment | UR |
| firefighter | LCS NP |
| pickles | UR |
| illustrate | HCS NP |
| primordial | HCS P |
| commanded | HCS P |
| sideways | HCS P |
| mirrors | UR |
| taxpayer | UR |
| tumulus | UR |
| fire | LCS NP |
| training | LCS P |
| films | UR |

# APPENDIX H

## A description of the excluded data from Experiment 3

*The excluded responses to incorrectly primed target words*

| | RD (n = 25) | | | ND (n = 31) | | | Combined (N = 56) | | |
|---|---|---|---|---|---|---|---|---|---|
| Condition | Number excluded | Total number of responses | % of data | Number excluded | Total number of responses | % of data | Number excluded | Total number of responses | % of data |
| H-CS P (20 items) | 113 | 500 | 22.60 | 120 | 620 | 19.35 | 223 | 1120 | 19.91 |
| L-CS P (21 items) | 141 | 525 | 26.86 | 159 | 651 | 24.42 | 300 | 1176 | 25.51 |

*The excluded recognition speeds to incorrectly primed target words*

| | RD (n = 25) | | | ND (n = 31) | | | Combined (N = 56) | | |
|---|---|---|---|---|---|---|---|---|---|
| Condition | Number excluded | Total number of responses | % of data | Number excluded | Total number of responses | % of data | Number excluded | Total number of responses | % of data |
| H-CS P (20 items) | 113 | 500 | 22.60 | 120 | 620 | 19.35 | 223 | 1120 | 19.91 |
| L-CS P (21 items) | 141 | 525 | 26.86 | 159 | 651 | 24.42 | 300 | 1176 | 25.51 |

*The excluded incorrect response recognition speeds*

| | RD (n = 25) | | | ND (n = 31) | | | Combined (N = 56) | | |
|---|---|---|---|---|---|---|---|---|---|
| Condition | Number excluded | Total number of responses | % of data | Number excluded | Total number of responses | % of data | Number excluded | Total number of responses | % of data |
| H-CS P (20 items) | 94 | 500 | 18.80 | 89 | 620 | 14.35 | 183 | 1120 | 16.34 |
| L-CS P (21 items) | 79 | 525 | 15.05 | 103 | 651 | 15.82 | 182 | 1176 | 15.48 |
| H-CS NP (20 items) | 146 | 500 | 29.2 | 151 | 620 | 24.35 | 297 | 1120 | 26.52 |
| L-CS NP (19 items) | 105 | 475 | 22.11 | 133 | 589 | 22.58 | 238 | 1064 | 22.37 |

*Note.* H-CS NP incorrect = the number of incorrect responses to non-primed words from the high saliency story; H-CS P incorrect priming = H-CS primed words that were preceded by an incorrect response to a H-CS non-primed word; L-CS NP incorrect = the number of incorrect responses to non-primed words from the low saliency story; L-CS P incorrect priming = L-CS primed words that were preceded by an incorrect response to a L-CS non-primed word; l-CS P incorrect response = L-CS primed words that were responded to incorrectly; Unrelated = the number of incorrect responses to words that were not from either story; Total Excluded = the total number of items excluded